DF-TR-94-10

Air Force Fire Protection Cost Risk Analysis

October 31, 1994

FINAL REPORT

HQ Air Force Civil Engineering Support Agency
Office of theAir Force Fire Marshal
139 Barnes Drive Suite 1
Tyndall AFB, FL 32403-5319

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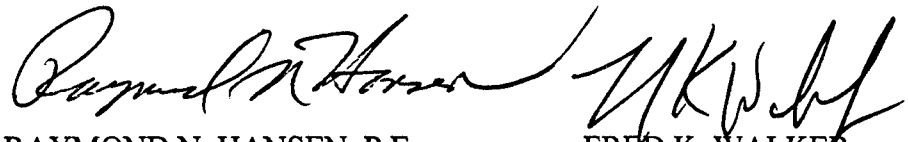

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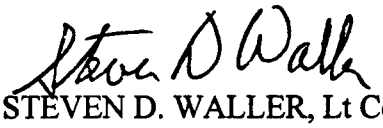

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This report discusses a series of analyses conducted to assess the impact of policy changes on fire losses. The analyses are based on available United States Air Force (USAF) fire incident data and the civilian National Fire Incident Report (NFIRS) database. An overall analysis of civilian and USAF fire departments found no clear difference in the performance of the two groups. The effect of fire department response time on fire losses was studied. A direct linear relationship between response time and fire loss was observed for both USAF and civilian fires. A cost model for estimating the annual base operating cost of USAF fire departments was developed. This model is a series of user-interactive spread sheets which allow specification of manpower and vehicles by the user. The combined use of the response time analysis and the cost model can be used to calculate the expected cost/risks of relocation of firefighting resources. A task-oriented work breakdown structure for USAF fire departments was conducted. A series of flowcharts were produced to diagram steps in firefighting.

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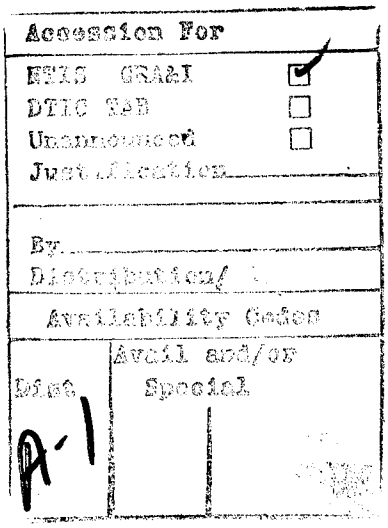
PREFACE

This report was prepared by Hughes Associates, Inc. (HAI), 6770 Oak Hall Lane, Suite 125, Columbia, Maryland 21045, under Contract No. N00014-90-C-2330, for the Department of the Air Force, WL-FIVCF-OL (Stop 37), Suite 2, 139 Barnes Drive, Tyndall Air Force Base, Florida 32403-5323.

This final report discusses a series of analyses which were conducted to provide the basis for assessing the impact of fire protection policy changes on fire losses. The effect of these changes on the annual operating costs was also investigated with a cost model.

This work was performed between October 1991 and December 1993. The AFCESA/DF project officer was Mr. Raymond Hansen.



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EXECUTIVE SUMMARY

A. OBJECTIVE

The purpose of this project was to provide methods for evaluating how United States Air Force (USAF) fire protection policy changes might affect the performance and operating costs.

B. BACKGROUND

The closing of fire stations and the reduction of firefighting personnel may seriously impact fire losses. It is necessary to evaluate the impact of such changes in fire protection policy.

C. SCOPE

This report includes several statistical analyses of USAF and civilian fire loss data. The first analysis provides an overall comparison between USAF and civilian fire loss data. The next analysis investigates the effect of response time on dollar losses and amount of damage. The last analysis includes a cost model which can be used to determine how manpower and vehicle assignments affect the annual operating cost for a particular base.

D. CONCLUSION

The comparison of losses for fire incidents in the USAF and overall civilian losses shows that the performance of the fire suppression activities of the USAF are comparable to the civilian sector. This comparison is only of fire suppression aspects of fire service activities and does not reflect the lower fire incident rate in the military relative to the civilian sector.

For both the USAF and civilian sector, there is a linear relationship between fire losses and response time. For occupancies with sufficient data to allow comparisons, the effect of response time on losses are comparable for the USAF and the civilian sector. Changes in average loss per minute change in response time were found to range from 0-$500 per minute.

A cost model for base fire protection has been developed to allow estimates of annual fire service costs. This model can be used to assess the changes in cost associated with changes in manpower and equipment.

Coupling the model for fire losses with the fire service cost model allows estimates of the economic trade-offs between protection costs and losses. This provides an important decision support tool for decisions regarding base fire protection services.

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SECTION I
INTRODUCTION

This report discusses a series of analyses which were conducted to provide the basis for assessing the impact of fire protection policy changes on fire losses. The analyses are based on available United States Air Force (USAF) and civilian fire incident data.

In this analysis, Air Force and civilian fire department data were tabulated using the Air Force fire incident database and the National Fire Incident Report (NFIRS) database. These data were used to provide an overall comparison of civilian and USAF fire department performance. This analysis showed no clear difference in the performance of the two groups. Furthermore, since the Air Force database is not large enough for an extensive analysis, data for important scenarios not available in the Air Force database were obtained from the NFIRS database.

In addition, the effect of department response time on fire losses was also studied. The purpose of this task was to determine how fire losses will be affected by delays in response time which may result from closing stations. A direct linear relationship between response time and fire loss was observed for both USAF and civilian fires.

A cost model for estimating the annual base operating cost was developed. This model is a series of user-interactive Excel worksheets which allow the manpower and vehicle assignments to be specified by the user. The combined use of the response time analysis and the cost model can be used to calculate the expected cost/risks of relocation of firefighting resources.

An analysis of task-oriented work breakdown structure for USAF Base/Facility Fire Departments was conducted and the product of this analysis is included in Appendix A in the form of flowcharts. The purpose of these charts is to diagram steps in the firefighting process, their interactions, and the role of manpower in the various tasks. The flowcharts provide a structured means for evaluating proposed changes in operation procedures. A retired Air Force Fire Chief, Ben Parton, was consulted during the preparation of these procedures.

SECTION II
A COMPARISON OF USAF VERSUS CIVILIAN FIRE DEPARTMENT PERFORMANCE

A. PURPOSE

The goal of this task is to establish a general indication of the performance of USAF versus civilian fire departments. This involves comparisons of loss statistics for various property types where side-by-side comparisons make sense. Data for Air Force fire departments were collected from an Air Force (AF) database which consists of approximately 8,000 incident records from April 1984 to September 1991. The records were analyzed for various fixed and mobile property categories. Civilian fire department data were obtained from the National Fire Incident Report (NFIRS) database which contains approximately 760,000 records for the year 1989. NFIRS includes incidents from all states and the District of Columbia except: MO, MS, NC, ND, NM, NV, OK, PA, WI, and WY. It is not known why there were no incidents from the first eight states. The database tape was damaged, so that data from the last two states could not be obtained for this report. The NFIRS incident records contained no narratives and has less information per incident that the Air Force database. Since the civilian database consists of many more incidents and a wider range of response times, it may be useful for analyzing particular Air Force scenarios which lack sufficient data. A comparison also provides the opportunity to benchmark overall performance of the fire safety systems.

B. DATABASES

1. General

The AF fire incident report and NFIRS databases both have records which contain incident background data, details of the structure(s) and/or vehicle(s) involved and their use, the casualties, estimated fire development, damage estimates, fire department response, and fire department actions. The military database is similar to NFIRS in categories and codes; however, significant differences do exist for some items. The codings for NFIRS and the Air Force database generally follow NFPA 901 (Reference 1) and DoD 6055.7-M (Reference 2), respectively.

2. Property Types Involved

Fire incidents are reported according to fixed or mobile property. The Air Force divides each property type into nine categories. The following list shows the fixed property categories:

(1) Public assembly property,
(2) Educational property,
(3) Institutional property,
(4) Residential property,
(5) Store and office property,
(6) Basic industry, utility, and defense property,

(7) Manufacturing property,
(8) Storage property, and
(9) Miscellaneous.

Based on this list, the following four categories were used to compare the Air force and civilian databases:

(1) All residential,
(2) Office and store,
(3) Storage, and
(4) Public assembly.

These four property types provide a fairly complete cross section of the categories that can be studied. Industrial and manufacturing has been excluded since this property type differs significantly between the two databases. The four categories chosen represent comparable properties for both databases, with the major differences being the exclusion of some subcategories in the Air Force coding which are in NFIRS. However, the Air Force codes include miscellaneous subcategories. In some cases, the Air Force does not include certain property type subcategories because they do not apply to the military. For example, office and store property contains a category Motor Vehicle or Boat Sales and Service (MVBSS) which is further divided into ten subcategories. The Air Force does not include five of the ten subcategories as they relate to vehicle and boat sales property. The other applicable subcategories are service stations. Thirty-three percent of the civilian office and store property incidents fall under MVBSS. Due to this large percentage, the NFIRS distributions discussed below were calculated with and without the five subcategories pertaining to vehicle and boat sales property. The results were nearly identical as these five subcategories only constituted 7 percent of the total office and store property incidents.

3. Dollar Loss

The estimated dollar loss associated with each incident is reported in both databases. Comparisons based on percent loss of total dollar value cannot be done since NFIRS does not contain total dollar values. Therefore, comparisons are made on a (corrected-for-inflation) dollar-to-dollar loss basis. The distributions presented in the results are established by categorizing the losses according to dollar ranges, such as $100 ranges for values of $0 to $1000, $1000 ranges for values of $1000 to $10,000, and so on. Each range is represented by the median value (e.g., range $300-$400 is represented by $350).

4. Casualties

Casualties are reported in both databases as number of injuries and as number of deaths. Injuries and deaths are further categorized according to "fire service" or "other" in the NFIRS database. The Air Force does not make this distinction. Comparisons are made by reporting total number of casualties.

5. Flame and Smoke Damage

The extent of the flame damage and smoke damage categories is reported by the Air Force using the following designations:

(1) Confined to object of origin,
(2) Confined to part of room of fire origin,
(3) Confined to room of origin,
(4) Confined to fire division compartment origin,
(5) Confined to floor of origin,
(6) Confined to building of origin,
(7) Extended beyond building of origin,
(8) Not a structure fire, and
(9) No damage of this type.

For the extent of flame damage, the civilian database (NFIRS) includes codes 1-7, does not include 8 and 9 and includes a code 0 (Undetermined or not reported). The NFIRS coding for the extent of smoke damage is the same as for flame damage except for an additional code 8, which signifies no damage. Fire and smoke damage is not reported well in NFIRS. Typically, 15 to 40 percent of reported incidents were missing damage information. It was learned that some states, such as California, do not even include flame and smoke damage on the incident reports.

This system is somewhat subjective (2 and 3 for instance) and different structures sustaining the same amount and extent of damage could have different labels (5 and 6). Also, only incidents involving a structure are evaluated with this system (about 60 percent of all fixed property incidents). It is useful, however, as an independent evaluation of the approximate trend of the percent damage.

In this study, the extent of damage type is reported as the percent frequency of valid incidents. A valid incident is one in which damage is reported with codes 1 to 7 and, in the case of smoke damage, a "No damage of this type" response. This method eliminates the bias of missing data and creates an equal basis for the comparison of the databases.

C. SELECTION OF RECORDS

The records used were restricted to those in which the fire department was responding to a fire, explosion or fuel spill. Initially, records were not restricted to those with a fire in progress when the fire department arrived and that were extinguished by the fire department. However, Office and store property and Storage property were evaluated later with the restriction that the fire was extinguished by the fire department. To reduce the number of erroneous data, only records with loss values between 0 and a value of all 9's in all available fields were accepted.

D. RESULTS

The number of incidents corresponding to the categories studied is shown in Table 1. The civilian database provides 20 to 70 times more incidents for one year than the Air Force does for a 7-year period. Overall, the Air Force does a better job of reporting incidents. The civilian database includes more codes relating to unreported/ undetermined damages and losses, and missing information than does the Air Force database.

TABLE 1. FREQUENCY OF EVENTS FOR FIXED PROPERTY USES

		Number of Incidents	
		Air Force	NFIRS
1.	All residential	2,698	198,496
2.	Office and store	386	23,546
3.	Storage	398	7,597
4.	Public assembly	340	12,156

The distribution of estimated dollar loss, number of casualties, and extent of flame and smoke damage from NFIRS and the Air Force database are shown for each category in Figures 1 to 16. The distribution of the estimated dollar loss is presented in two ways: (1) the percent of total incidents with a given loss and (2) the cumulative percent of incidents with dollar losses below the given value. As few incidents (less than 0.1%) had more than 10 casualties, distributions are presented as the percent of total incidents with one through 10 casualties. The distributions of the extent of flame and smoke damage are presented as the percent of total valid cases for which a degree of damage occurred (see Section II, C, 5).

Figures 1 to 3 show the loss and damage distributions for all residential fires. As shown in Figure 1, the estimated dollar losses are quite similar between the NFIRS and Air Force data. The results in Figure 2 show better casualty statistics for the civilian data. Ninety-five percent of the NFIRS incidents had no casualties, and about 4 percent had only one. The Air Force data show that only 86 percent of the incidents had no casualties and over 11 percent had one casualty.

Although the distributions for the extent of flame damage are different, the trends are not distinct enough in regards to assigning a better performance to either the civilian or Air Force fire departments. The Air Force data shows 22 percent of the fires confined to the object of origin (code 1) and 52 percent confined to part of the room of fire origin (code 2); whereas, the civilian data shows about 42 and 20 percent, respectively. On the other hand, only about 6 percent of the Air Force incidents were

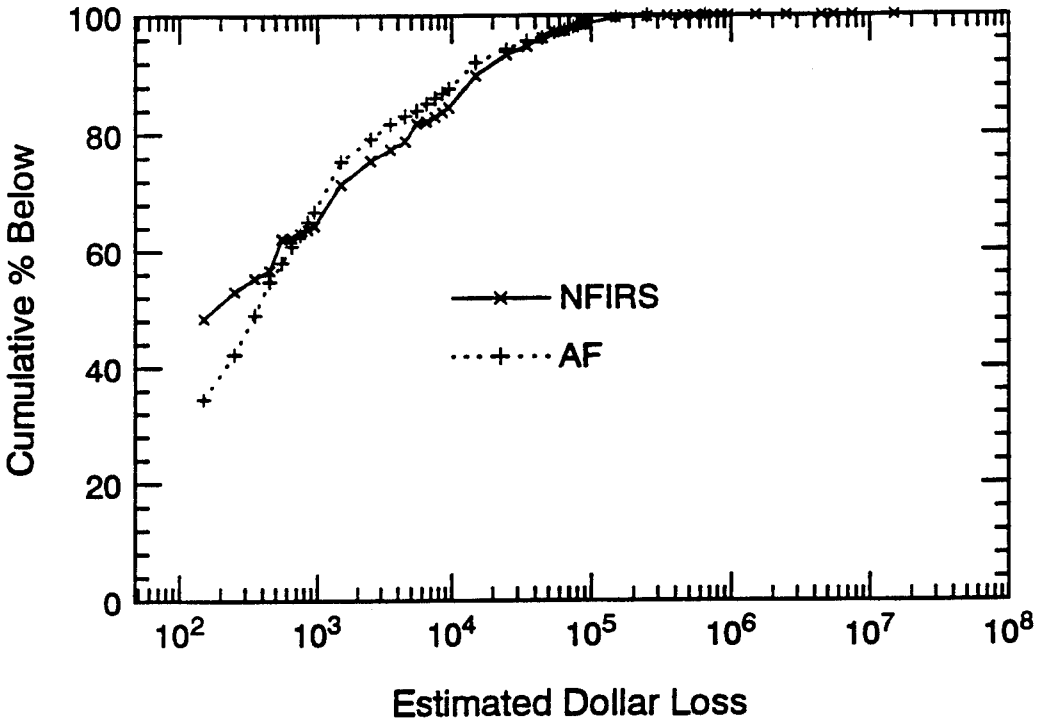


Figure 1. Frequency of Estimated Dollar Losses for Residential Fires

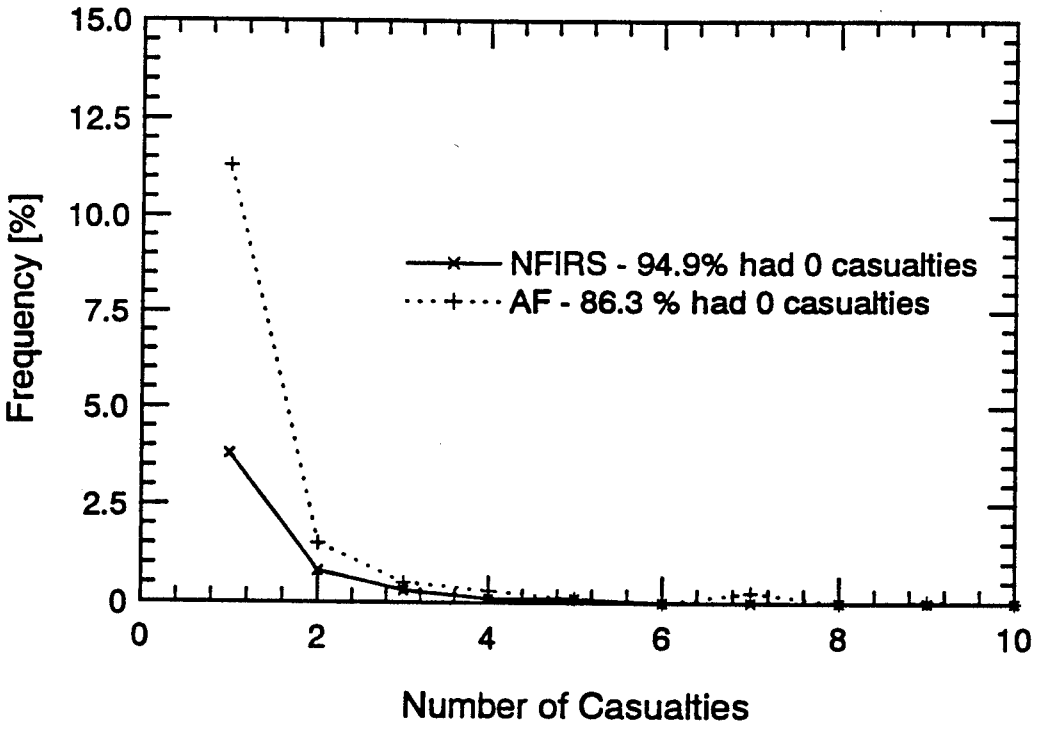
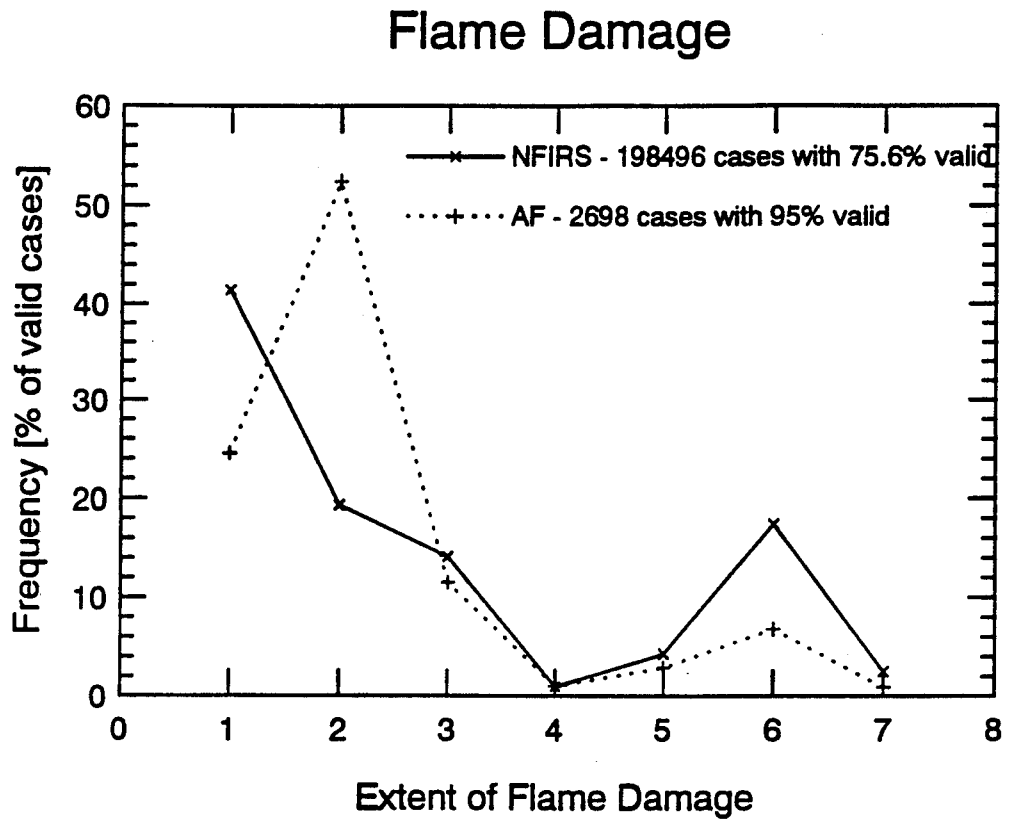


Figure 2. Frequency of Casualties Occurring in Residential Fires



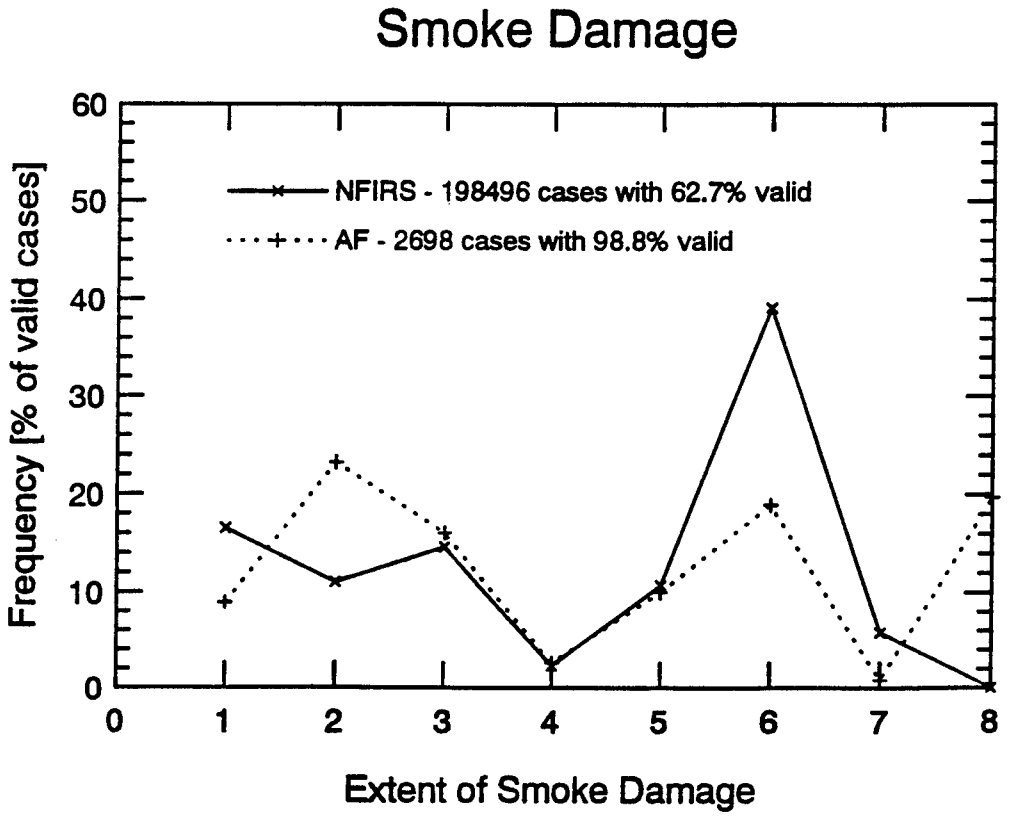


Figure 3. Extent of Flame and Smoke Damage Resulting from Residential Fires

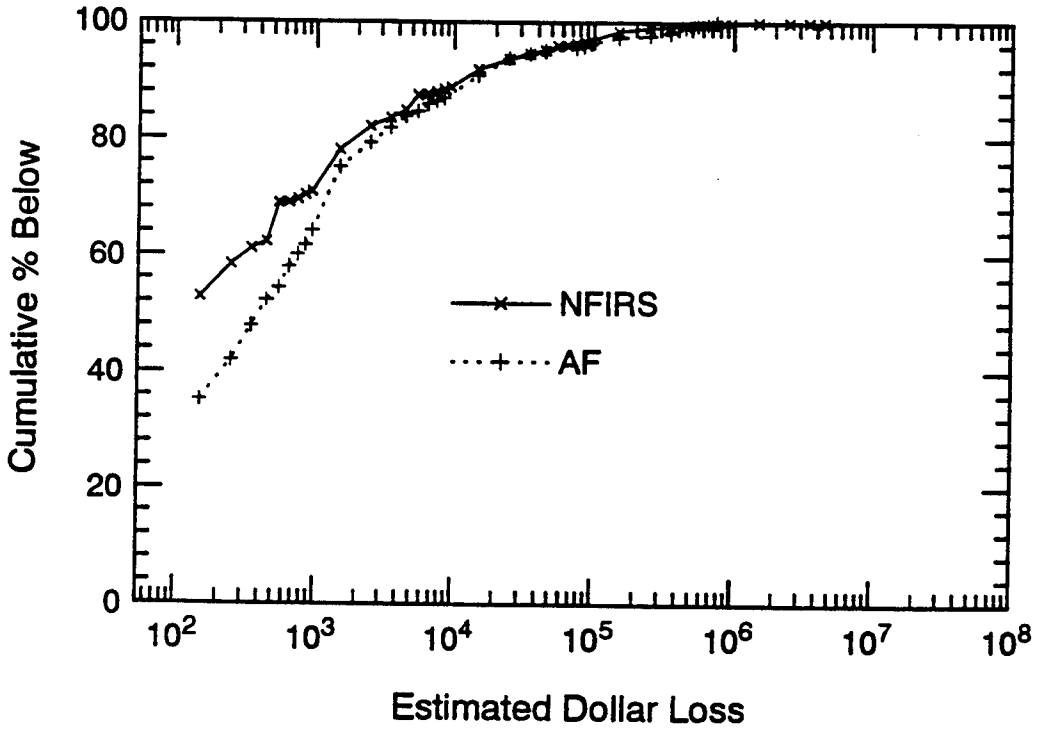


Figure 4. Frequency of Estimated Office and Store Dollar Losses

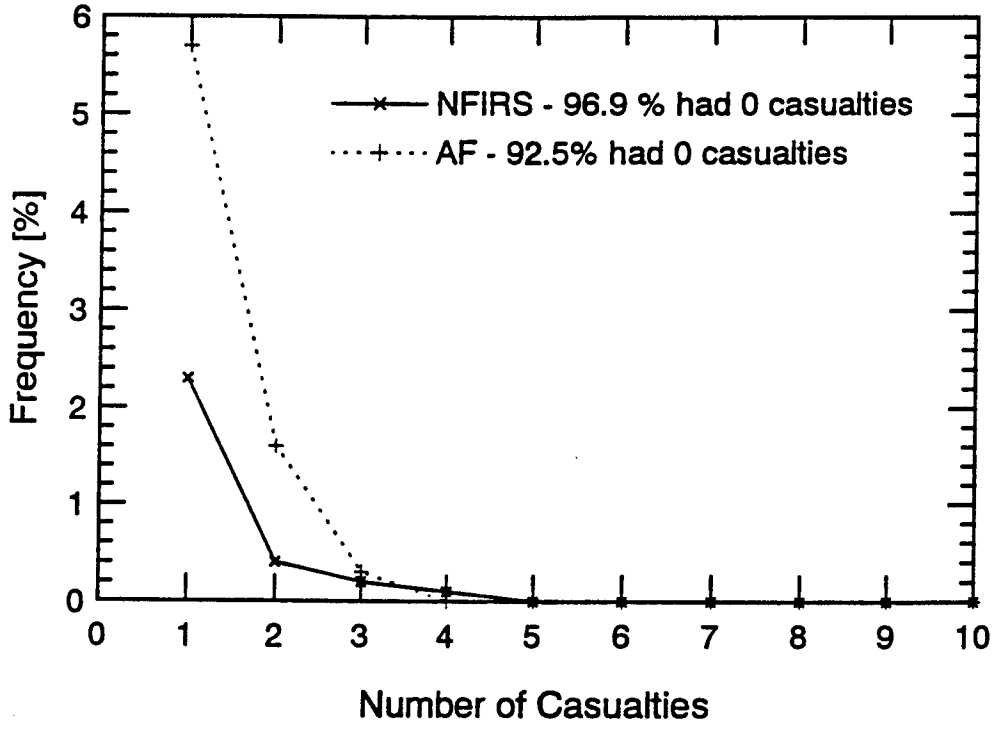
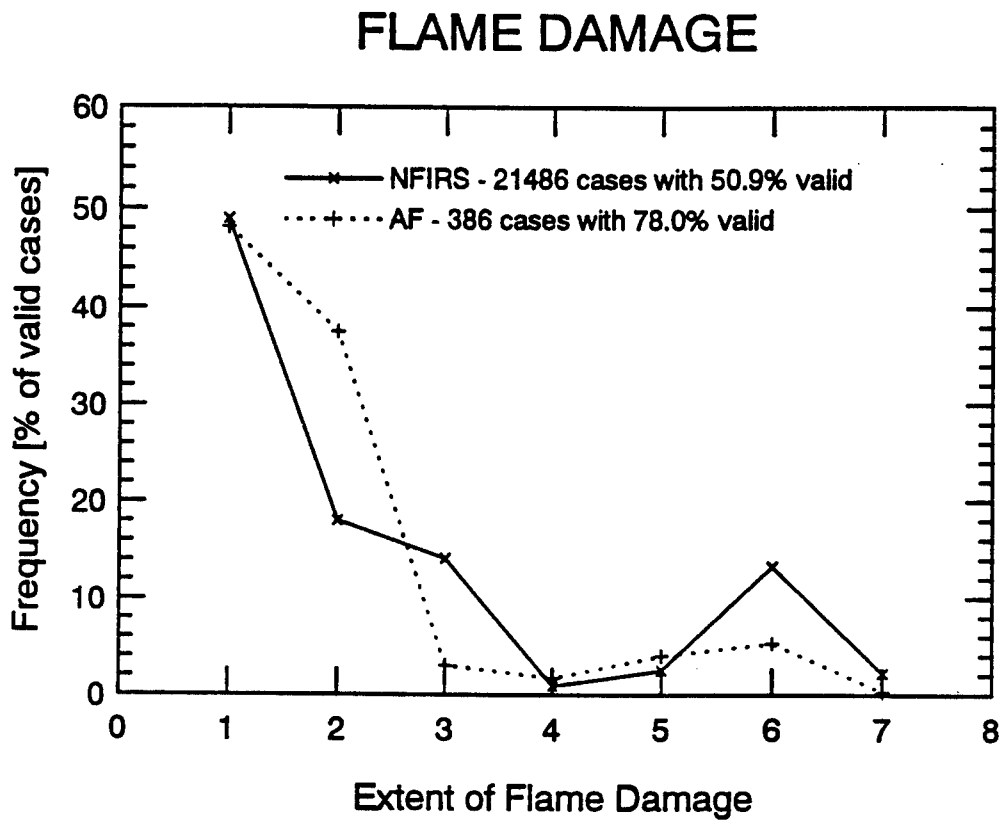


Figure 5. Frequency of Casualties Occurring in Office and Store Fires



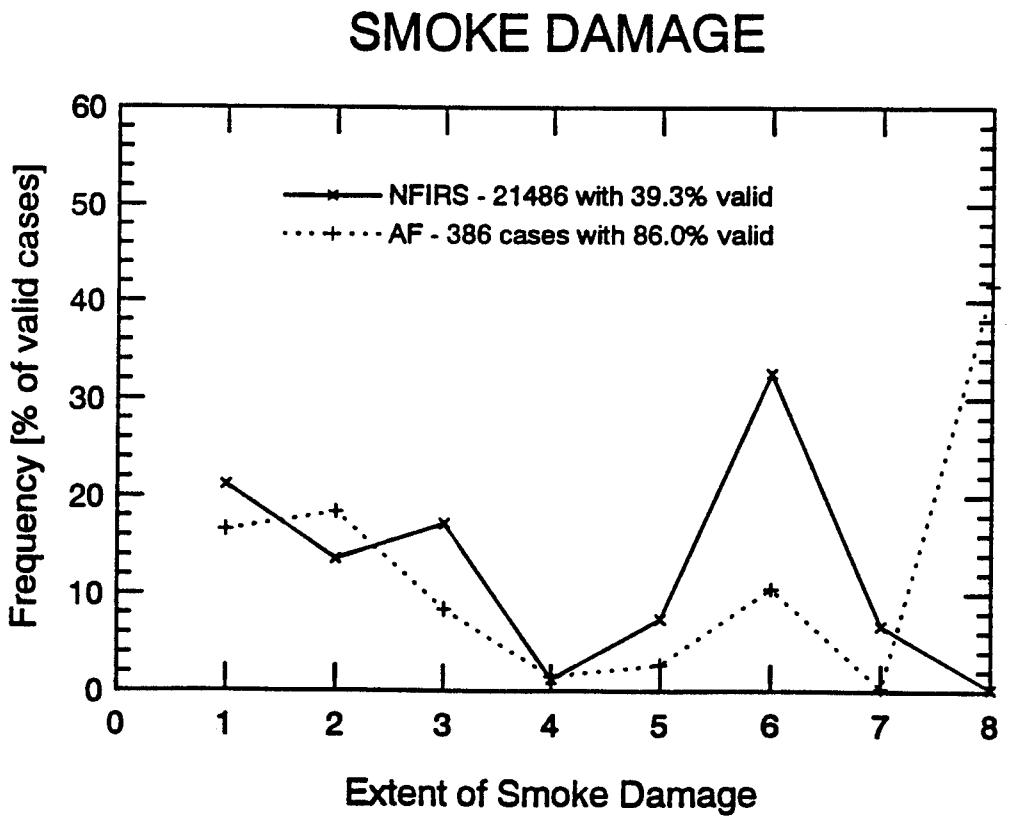


Figure 6. Extent of Flame and Smoke Damage Resulting from Office and Store Fires

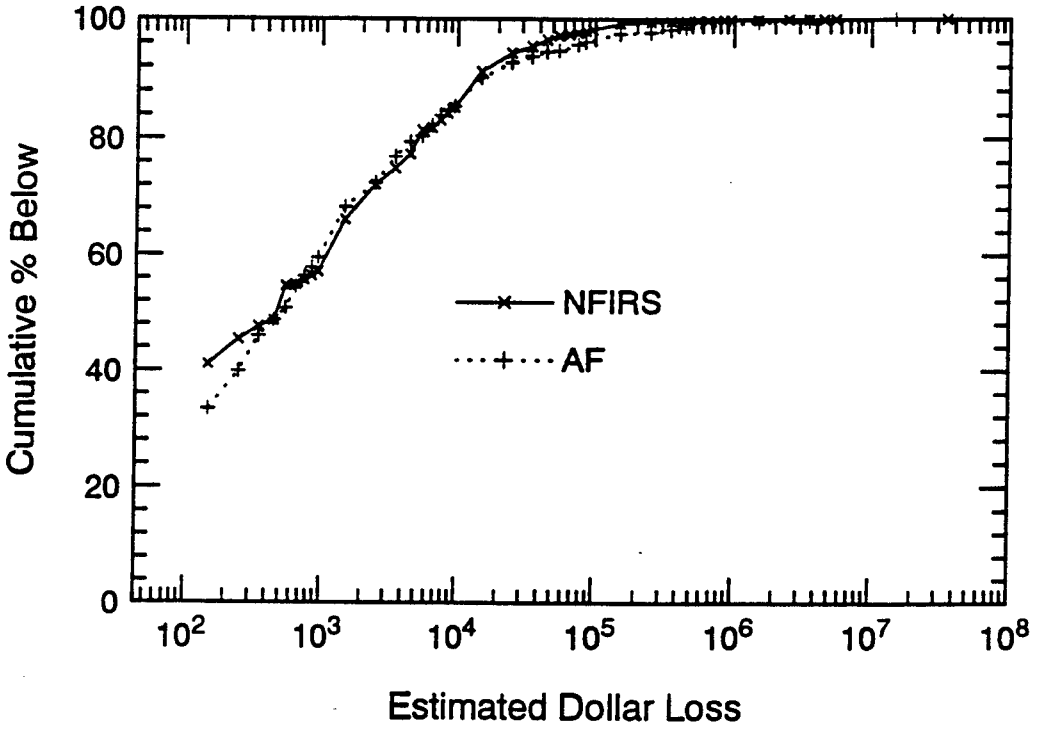


Figure 7. Frequency of Estimated Storage Dollar Losses

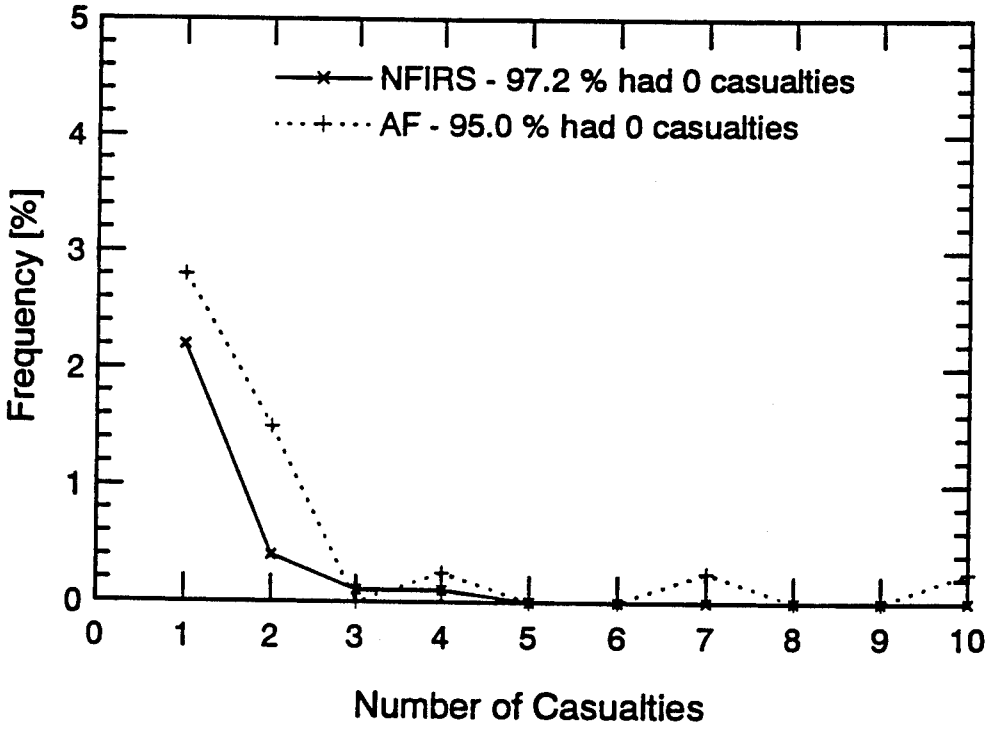
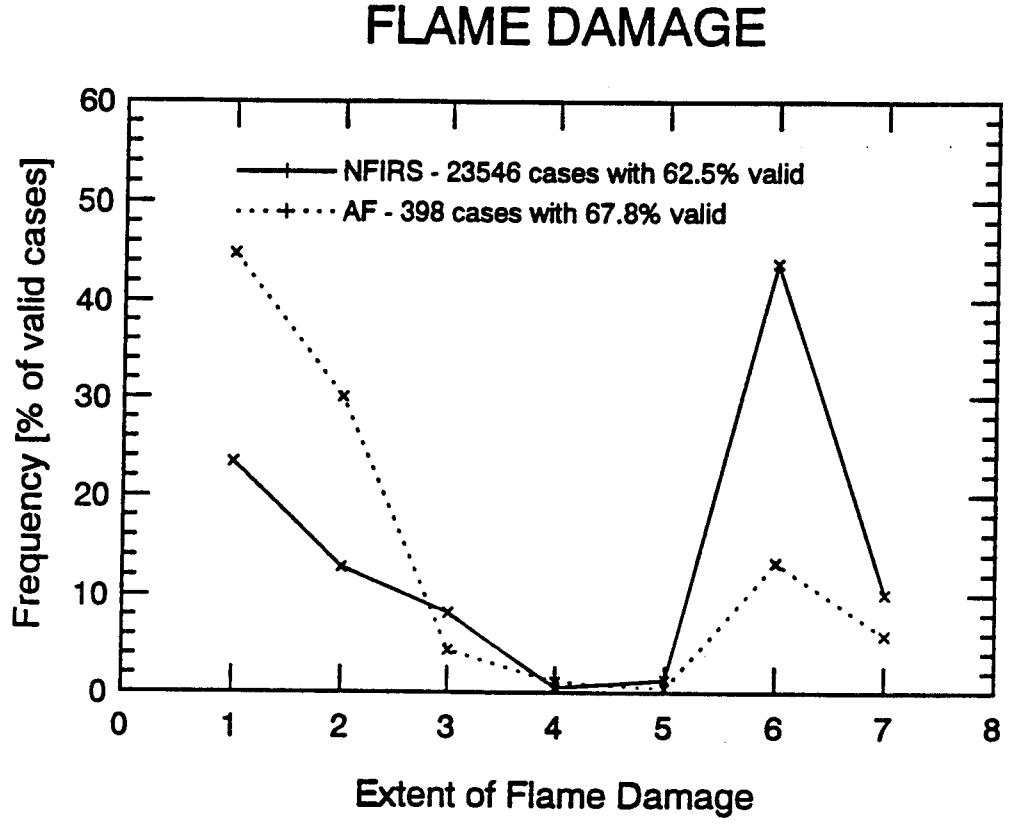


Figure 8. Frequency of Casualties Occurring in Storage Fires



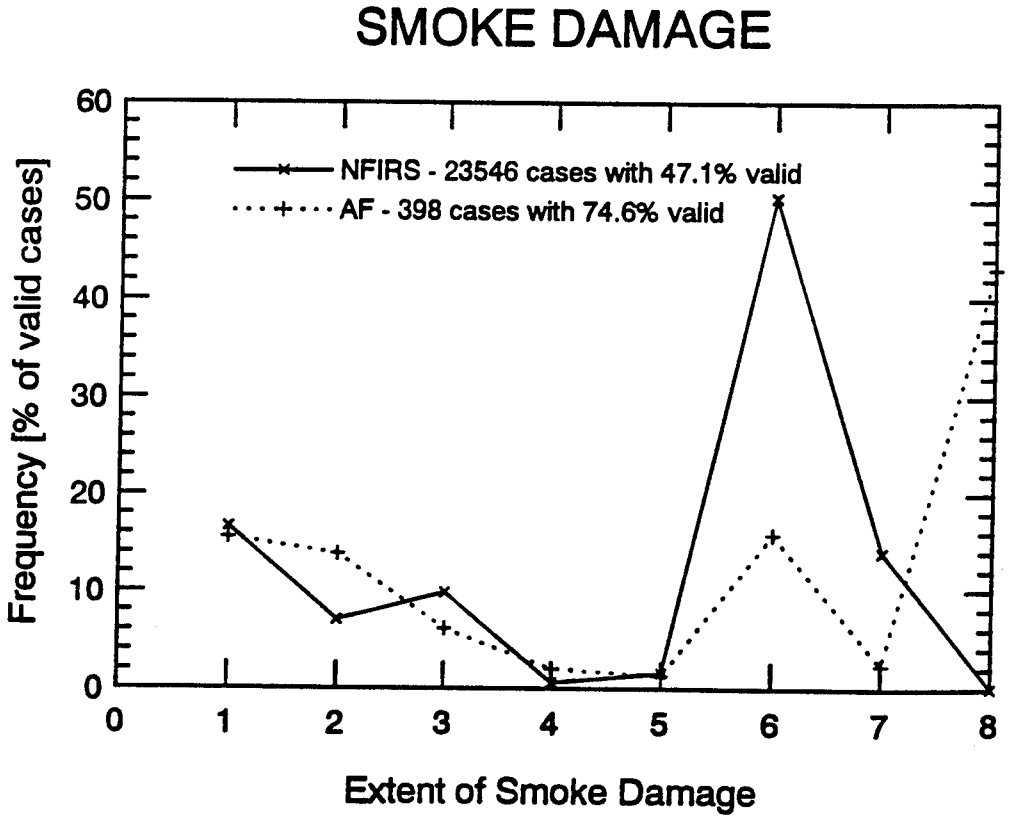


Figure 9. Extent of Flame and Smoke Damage Resulting from Storage Fires

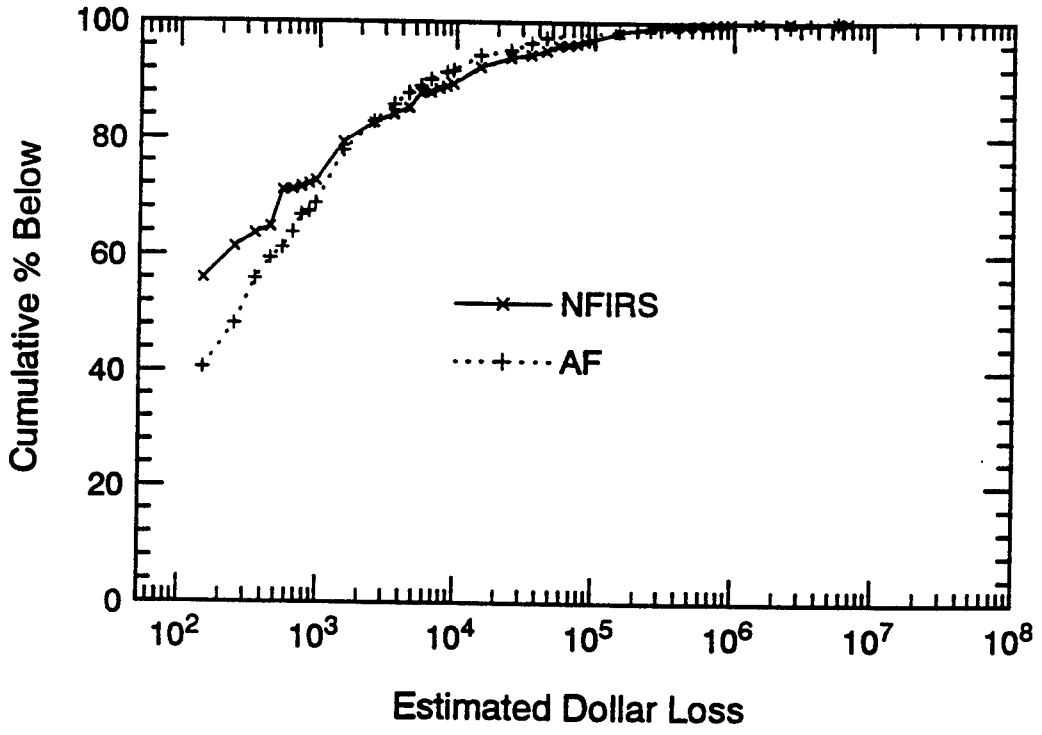


Figure 10. Frequency of Estimated Dollar Losses for Public Assembly Fires

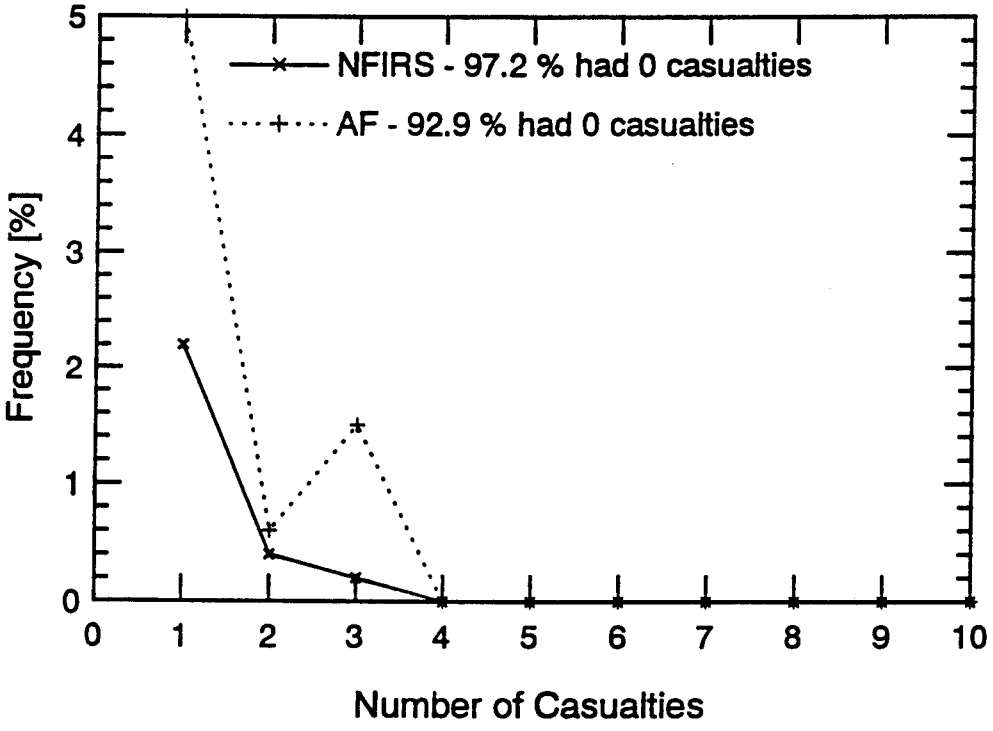
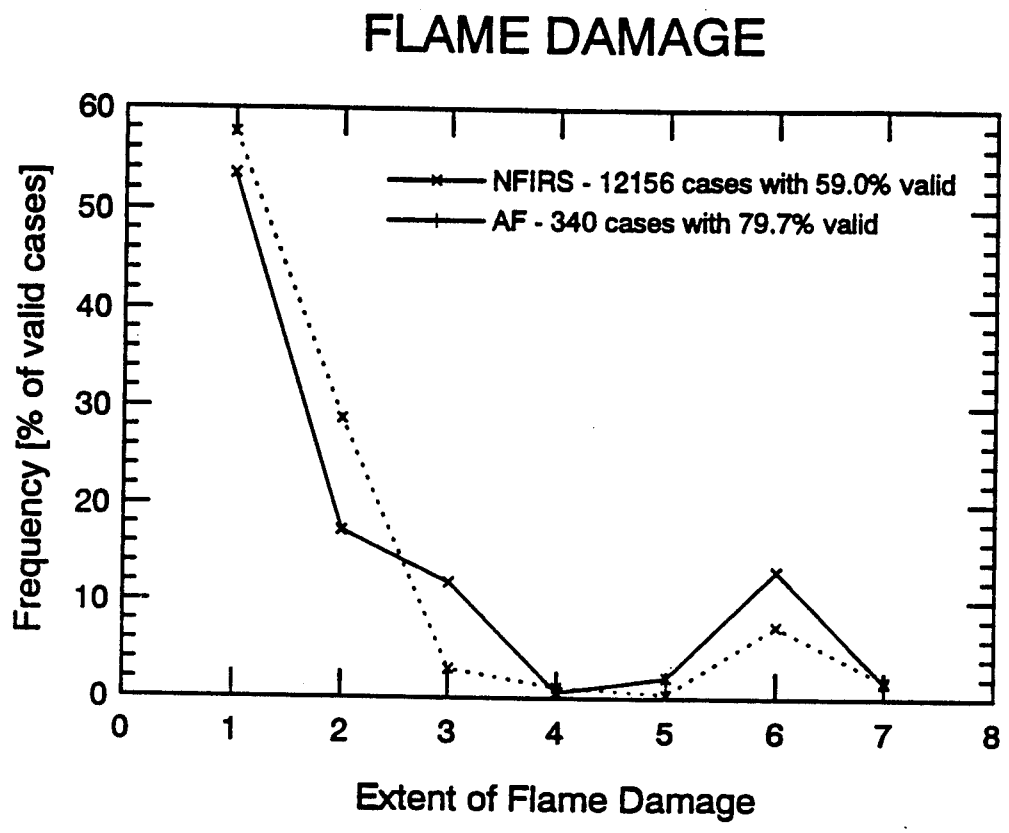


Figure 11. Frequency of Casualties Occurring in Public Assembly Fires



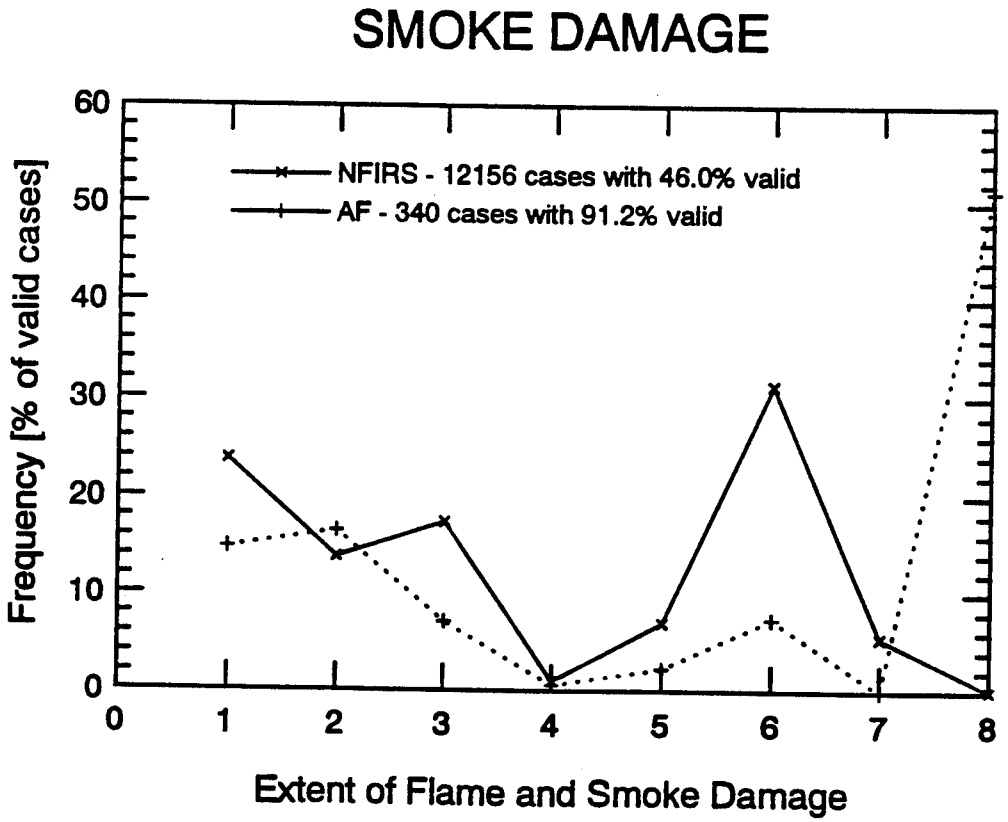
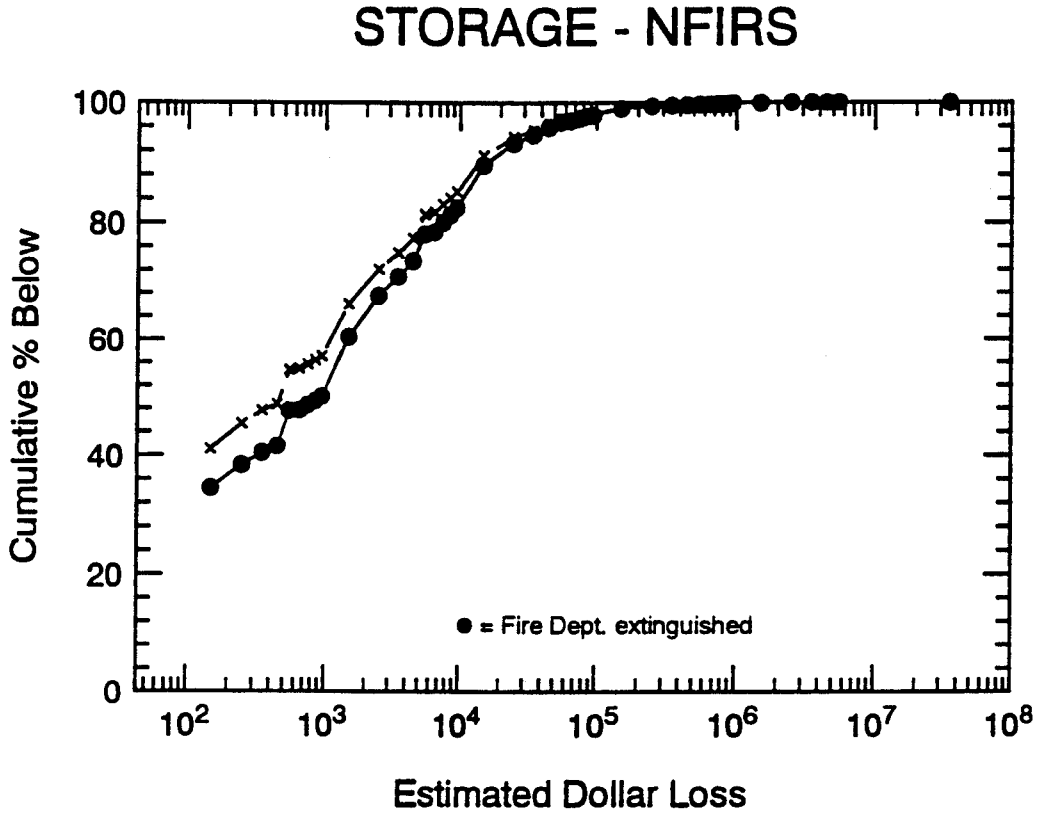


Figure 12. Extent of Flame and Smoke Damage Resulting from Public Assembly Fires



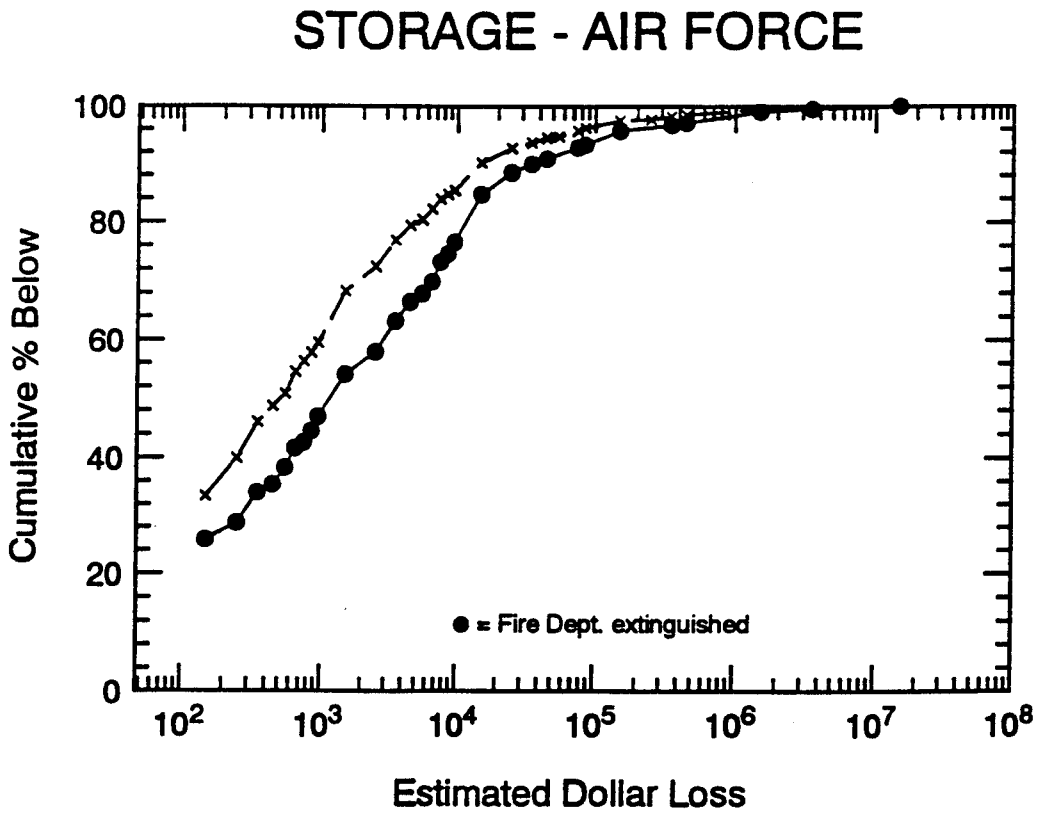
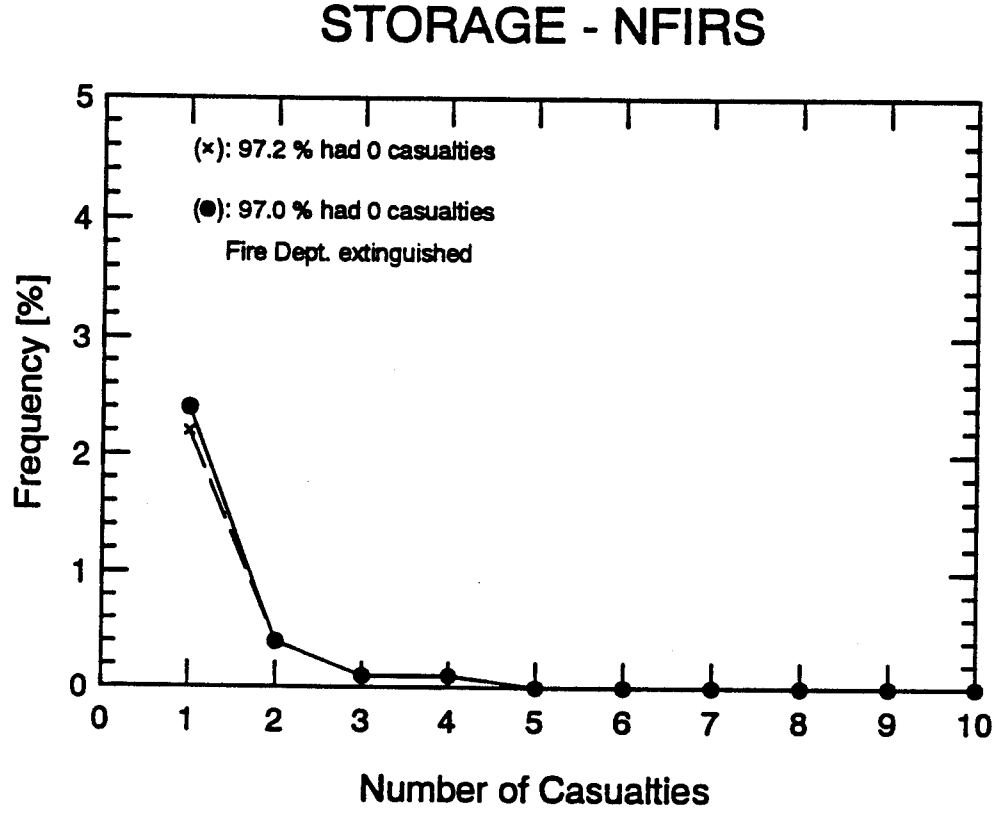


Figure 13. Frequency of Estimated Dollar Losses for Storage Fires



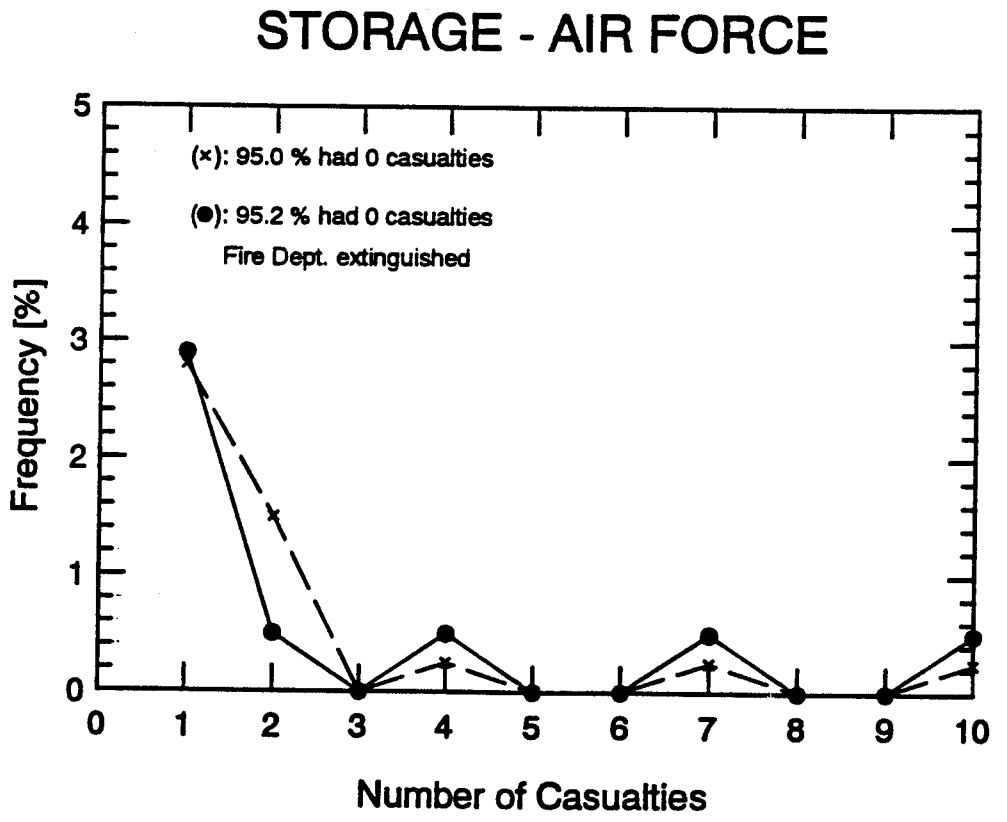
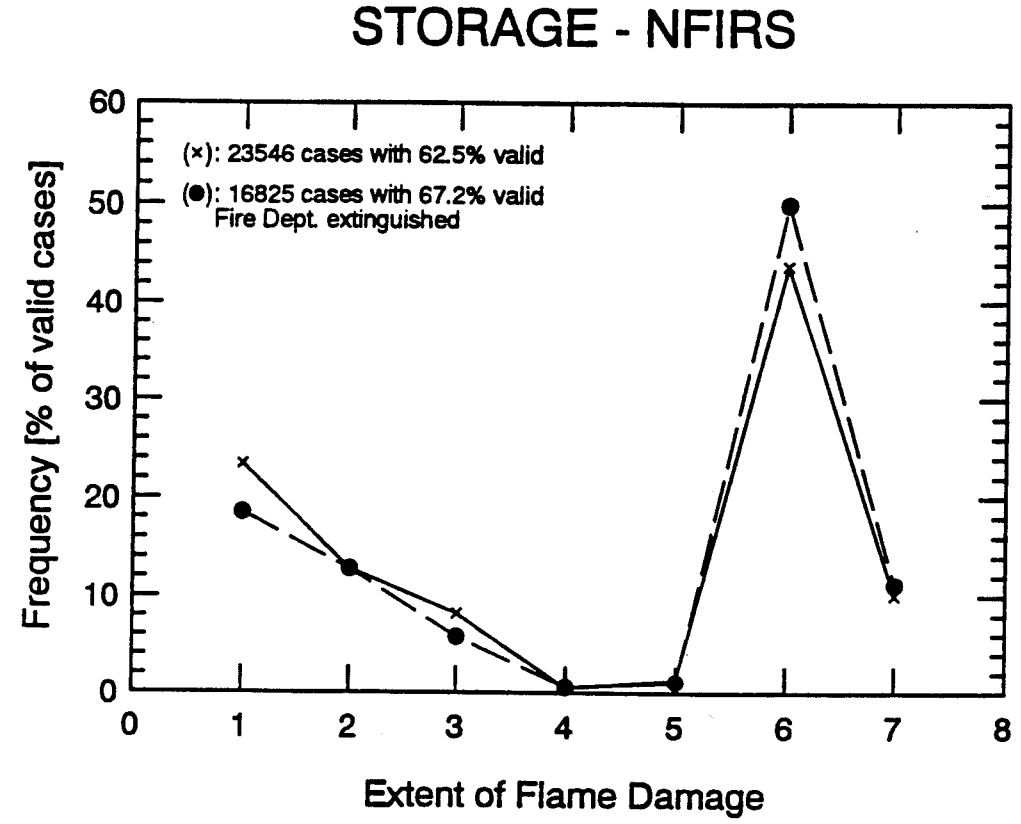


Figure 14. Frequency of Casualties Occurring in Storage Fires



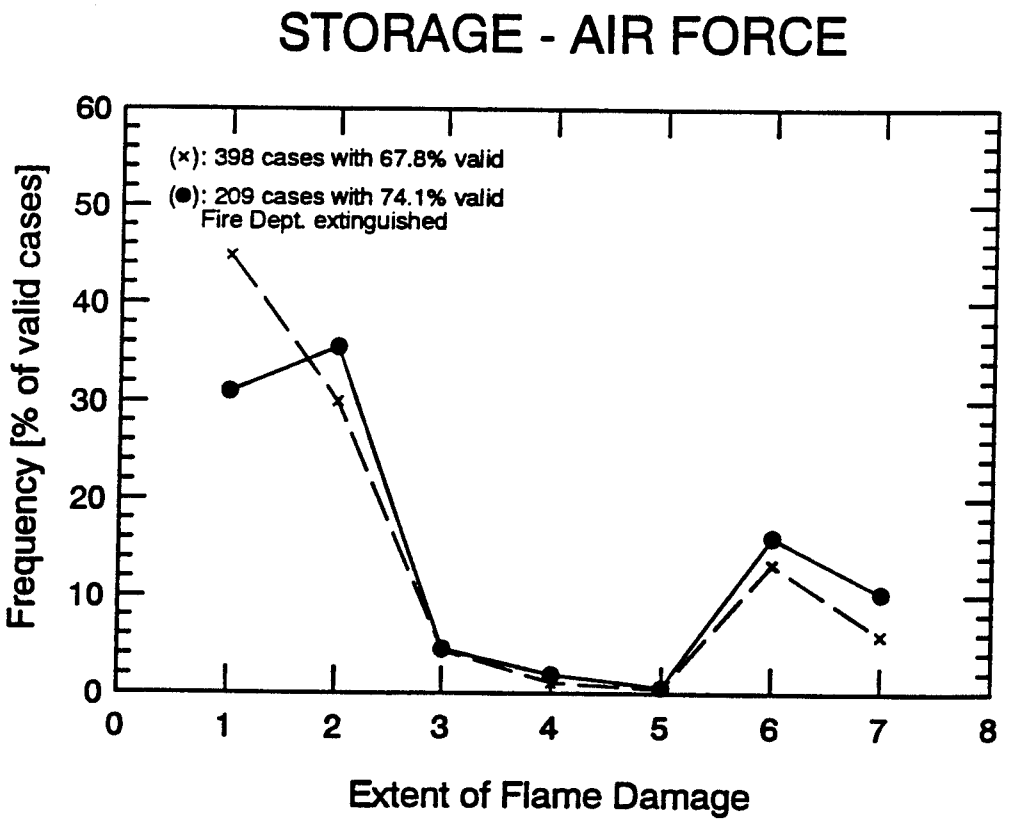
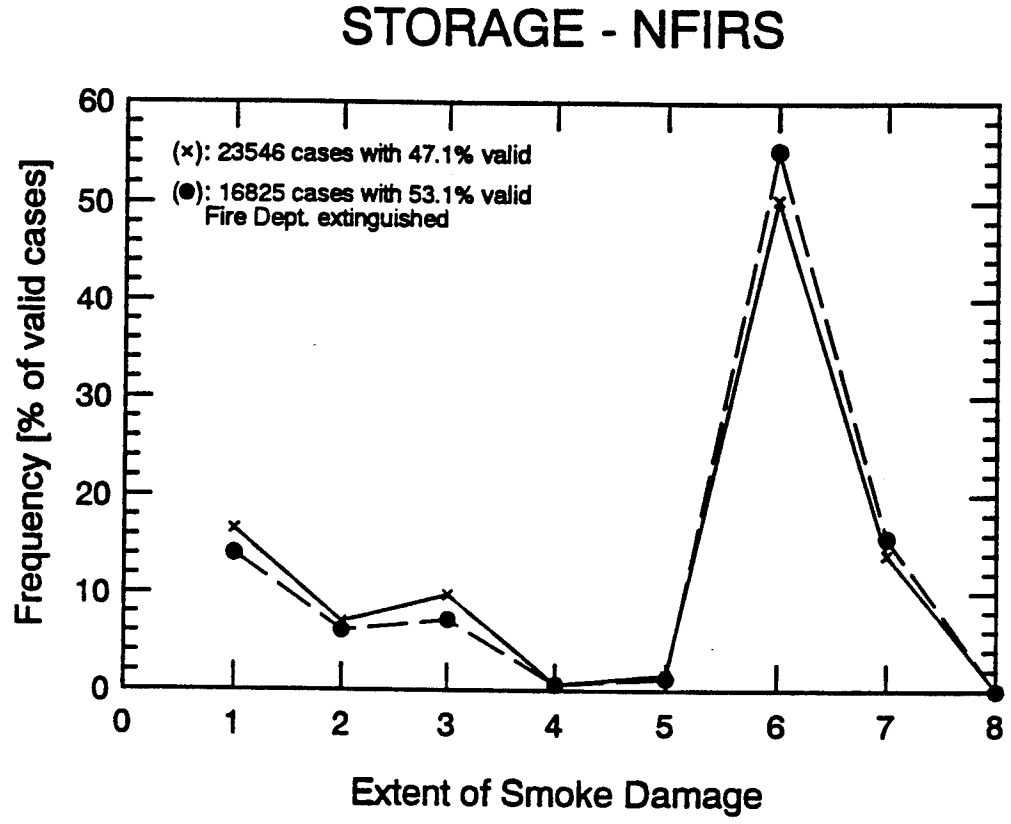


Figure 15. Extent of Flame Damage Resulting from Storage Fires



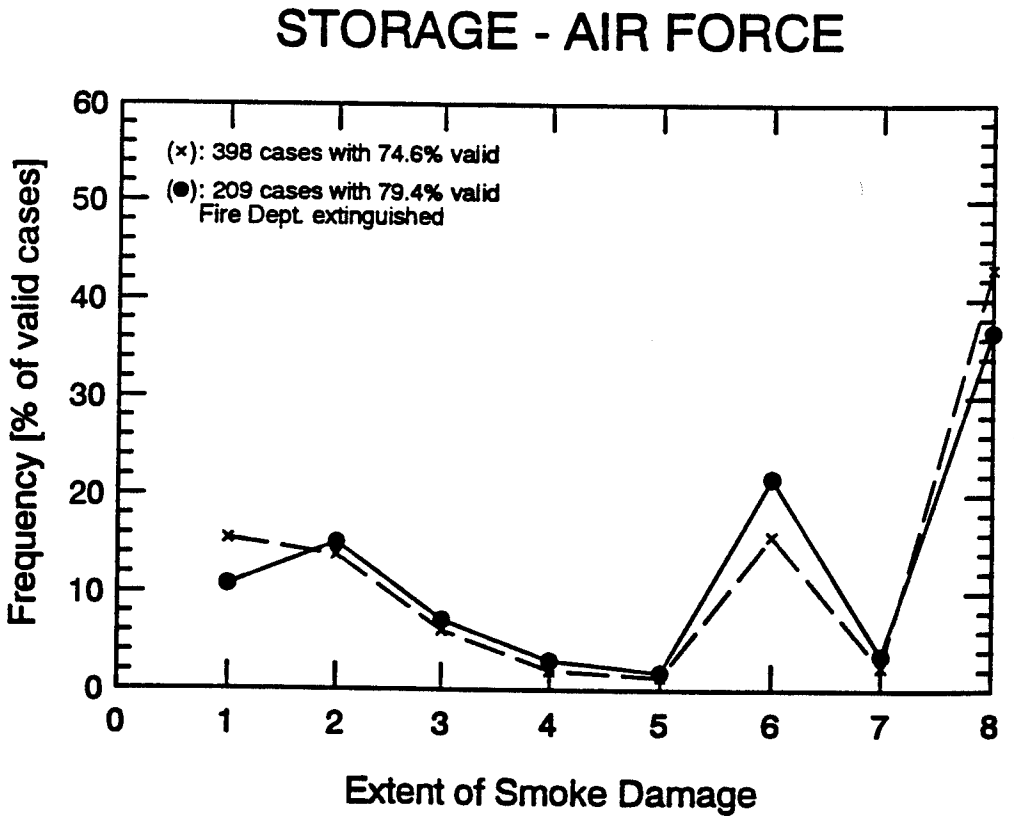


Figure 16. Extent of Smoke Damage Resulting from Storage Fires

confined to the building of fire origin (code 6) compared to 18 percent for the civilian incidents.

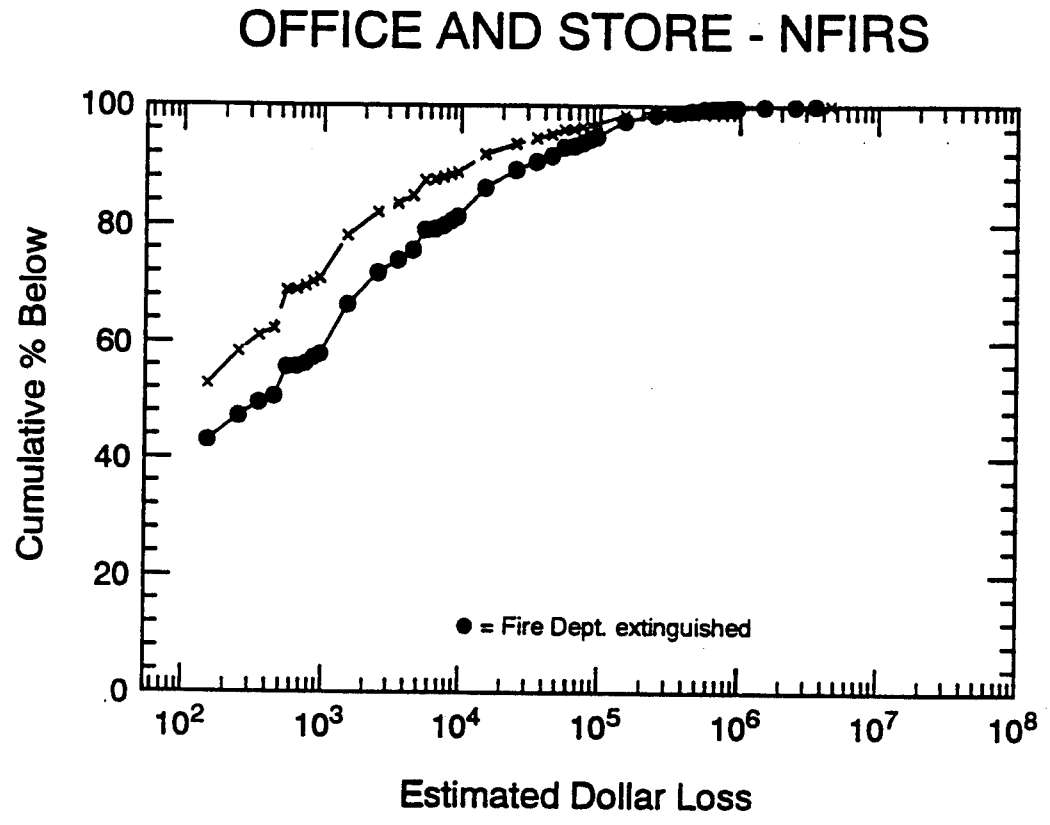
The data are fairly clear in showing a better performance for the Air Force in controlling smoke damage. Twenty percent of the AF incidents had smoke confined (code 6) to the building of fire origin, compared to 40 percent for the civilian incidents. Also, there were no civilian instances of no smoke damage; whereas, 20 percent of the Air Force incidents had no smoke damage (code 8).

The comparisons between the AF and civilian data for the other property types are basically the same as stated for all residential property. The only significant difference in the trends occurs for the extent of flame damage distributions. For the three other categories, there is a more distinct trend that the Air Force fire departments limited the extent of flame damage more than the civilian departments (Figures 4 through 12). For example, Figure 9 shows that approximately 44 percent of civilian storage property incidents had flames confined to the building (code 6), and only in 24 percent of the cases were flames confined to the object of origin (code 1). This is contrasted by the Air Force data which show only about 14 percent had flames confined to the building (code 6), and in 45 percent of the incidents, flames were confined to the object of fire origin (code 1).

It was thought that the inclusion of all incidents without regard to the method of extinguishment may have skewed the distributions unevenly and affected the comparisons. It is reasonable to assume that incidents in which fires are not extinguished by the fire department are generally characterized by little damage and no casualties. If this is the case, the database with more fire department extinguished fire incidents would produce distributions with greater degrees of damages and injuries.

Table 2 shows (for each property type), the percent of incidents in which the fire was extinguished by the fire department. There is no consistent trend for either the civilian or the Air Force fire departments having extinguished more of the fires for the incidents reported. This, coupled with the fact that the trends of damage and loss are consistent, independent of property type, would suggest that the method of extinguishment selection criteria has little effect on the results of this study. An analysis also bears this out.

Two property types (Storage, and Office and store) were analyzed with the additional selection criteria that the fire department extinguished the fire. Figures 13 to 16 show the comparison between fire damages and losses for storage property analyzed according to the selection criteria in Section II, D and with the additional FD method of extinguishment criteria. The effect of selecting only FD extinguished fires is similar for both the Air Force and the civilian data. The estimated dollar loss distributions in Fig. 13 show a shift toward higher losses as would be expected. There are small changes between the extent of smoke and flame damage which have little affect on the comparisons between the civilian and Air Force data. Figures 17 to 20 show similar results for office and store property.



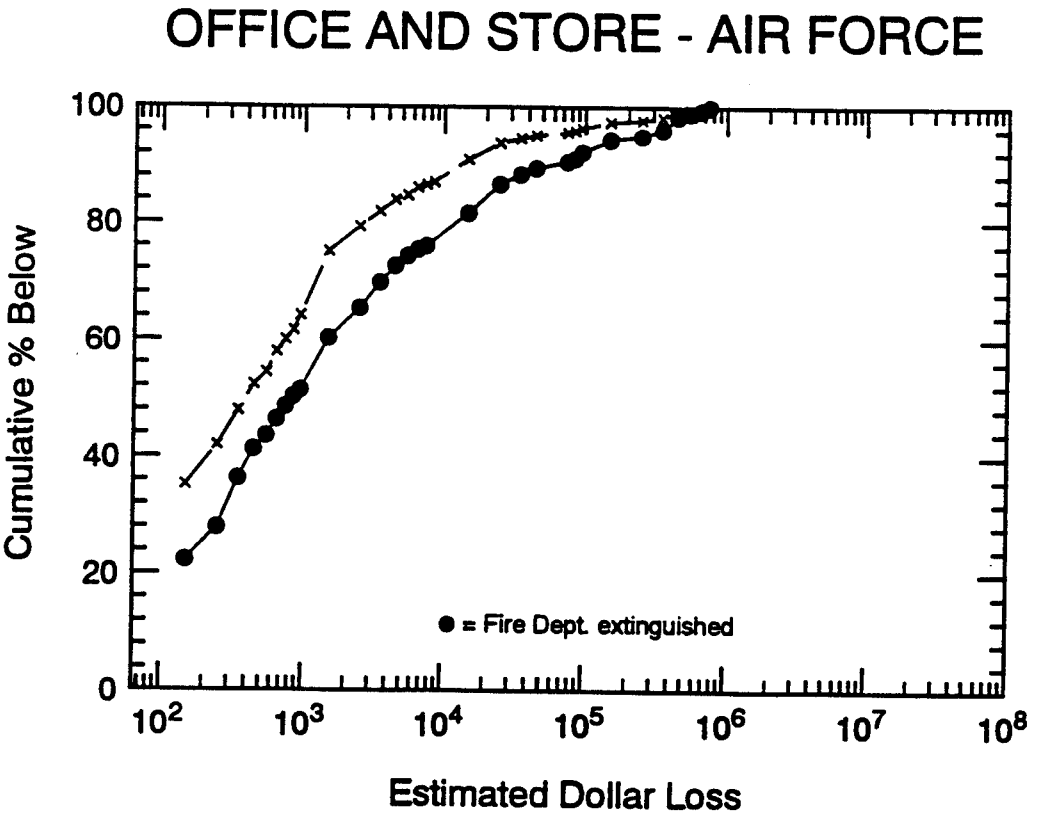
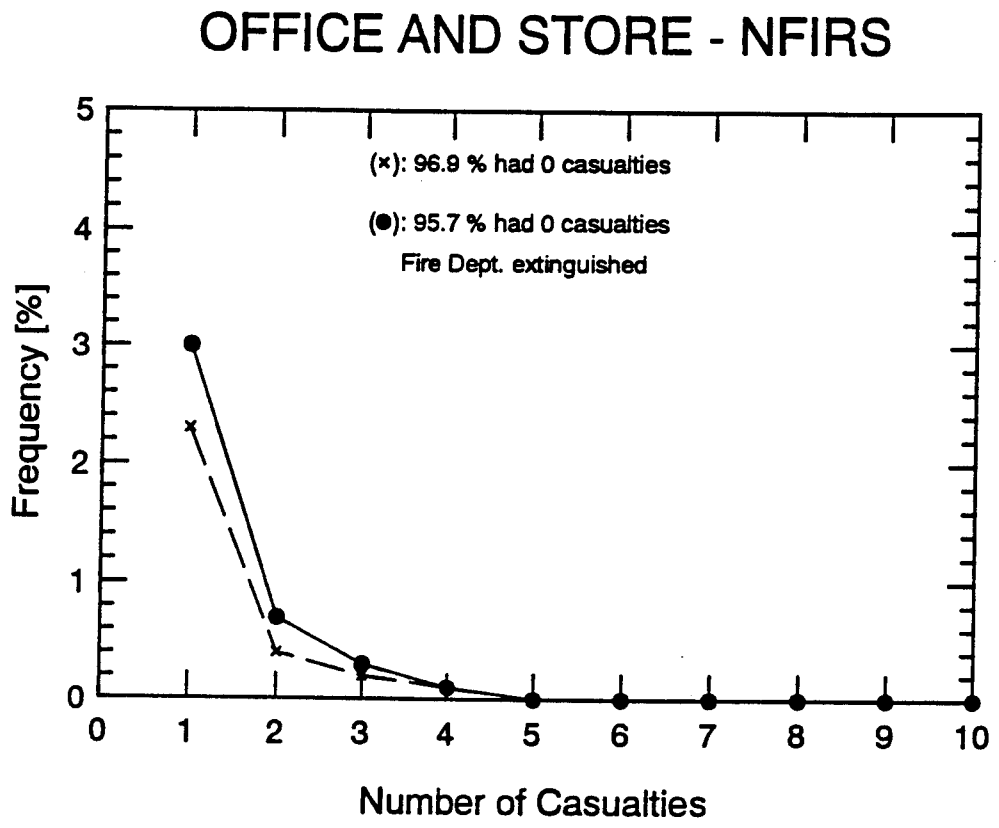


Figure 17. Frequency of Estimated Office and Store Dollar Losses



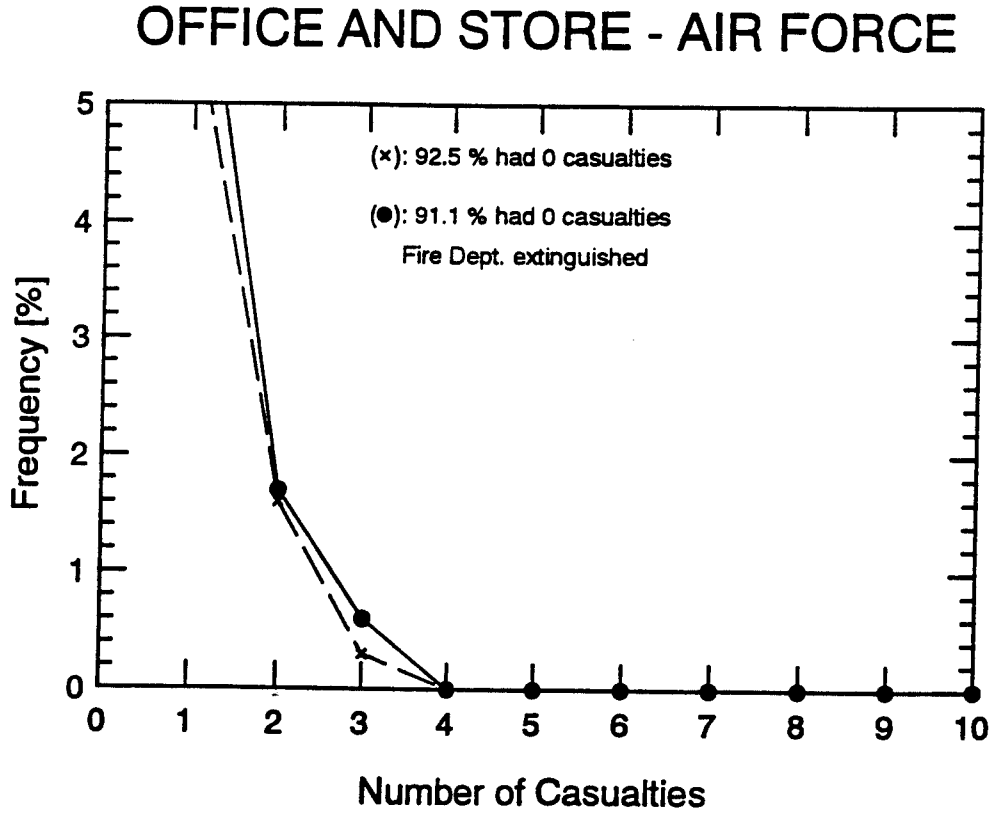
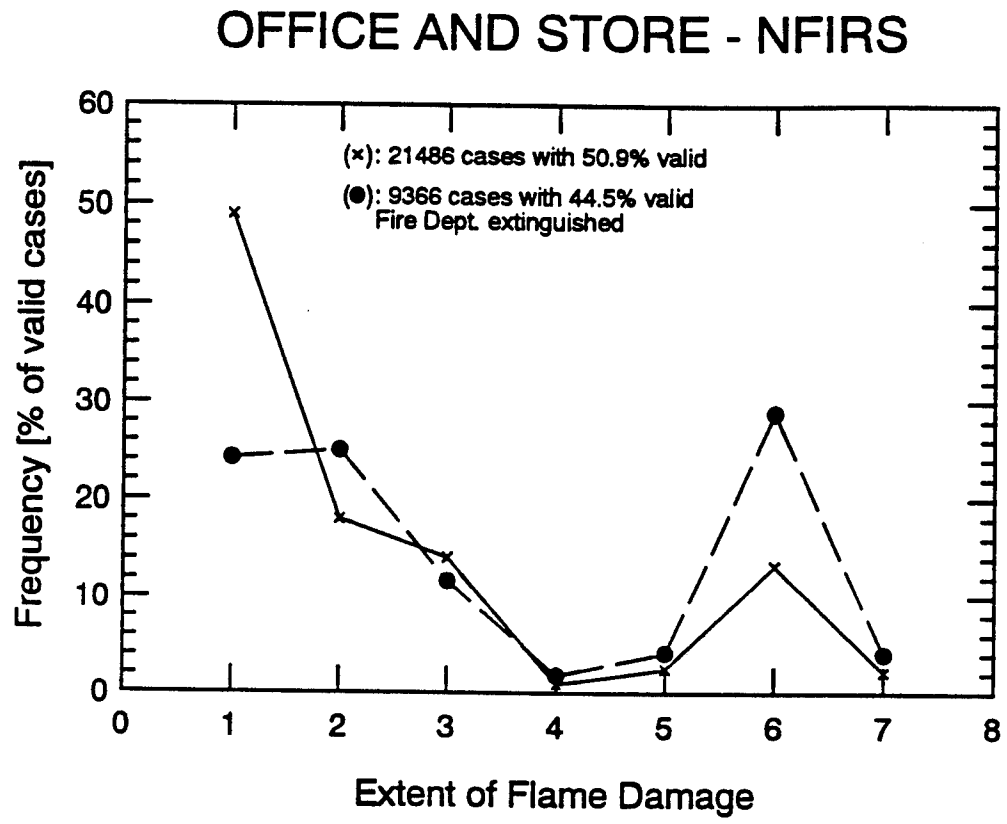


Figure 18. Frequency of Casualties Occurring in Office and Store Fires



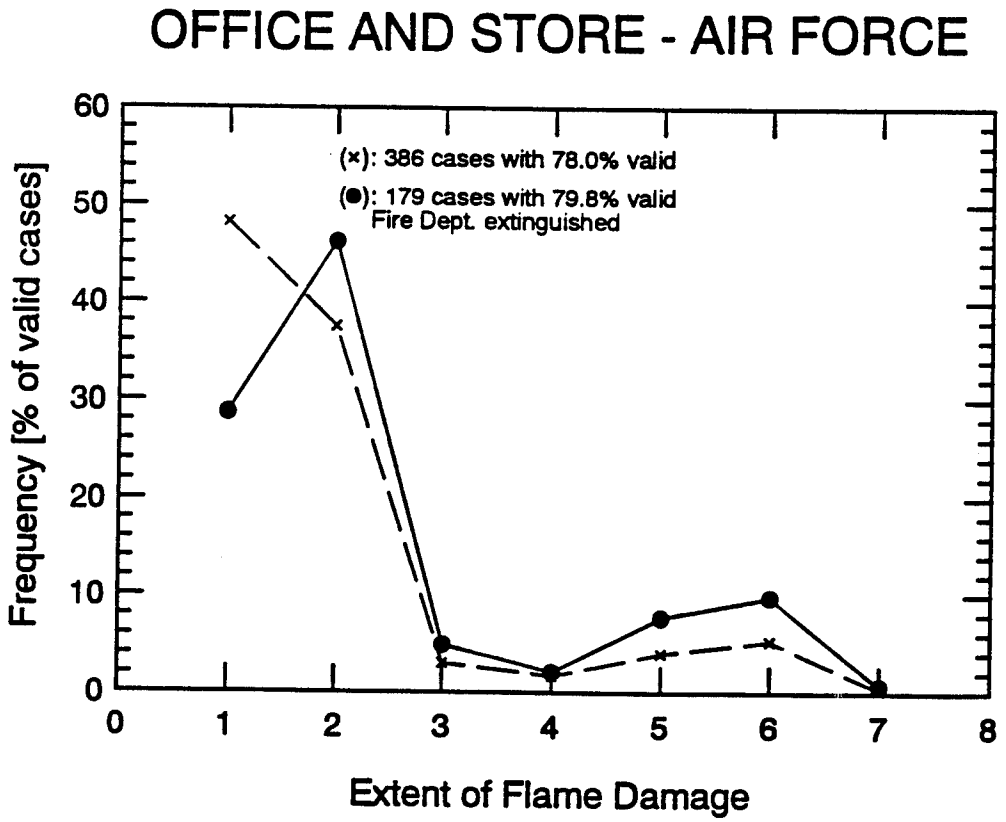
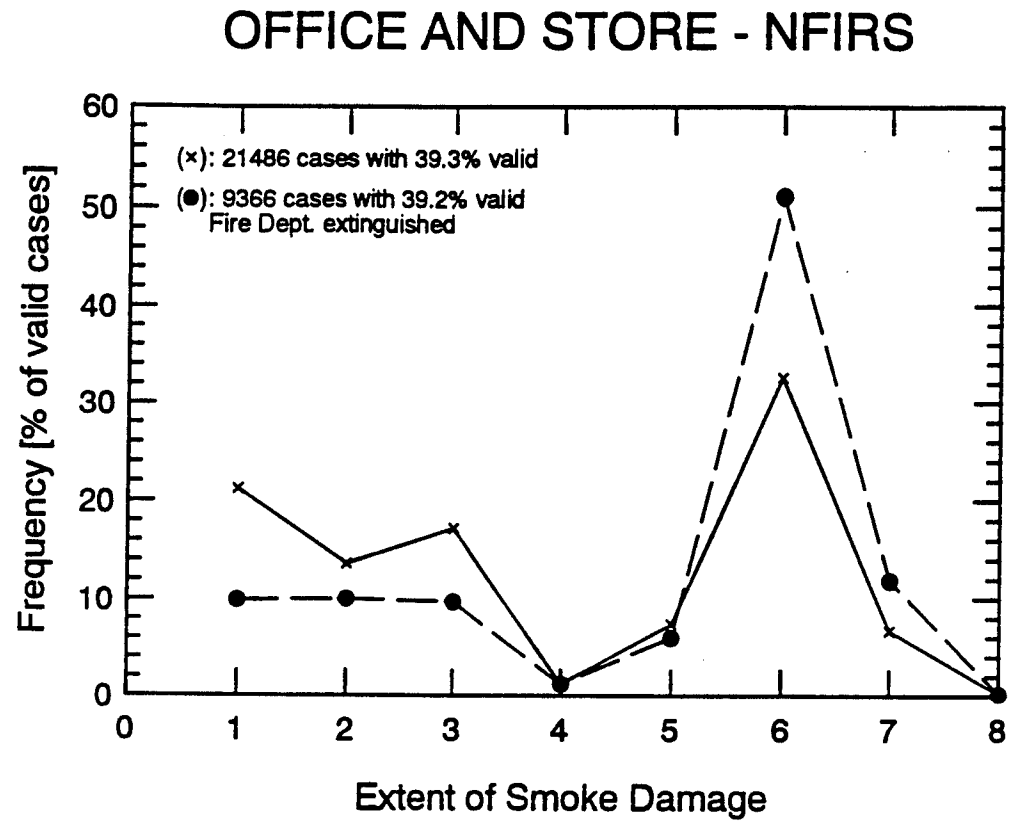


Figure 19. Extent of Flame Damage Resulting from Office and Store Fires



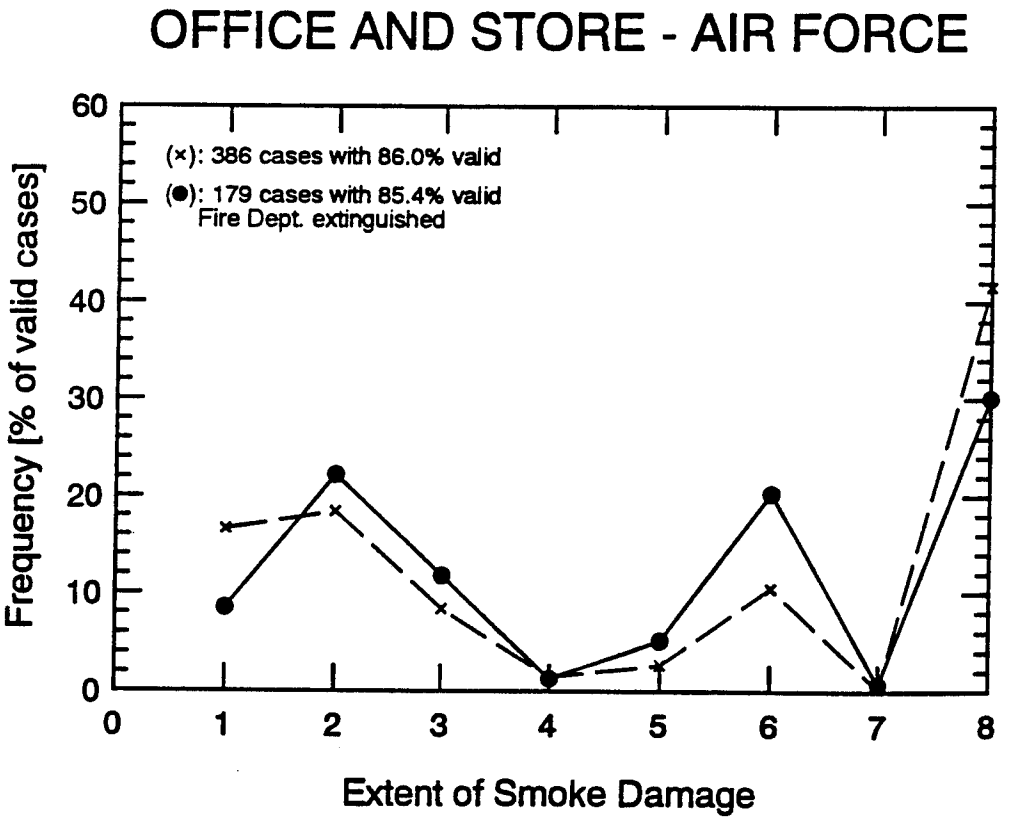


Figure 20. Extent of Smoke Damage Resulting from Office and Store Fires

TABLE 2. PERCENTAGE OF FIRES EXTINGUISHED BY FIRE DEPARTMENT

Property Type	Fire extinguished by Fire Department (%)	
	NFIRS	Air Force
All residential	41.5	36.2
Office and store	43.6	46.4
Storage	71.5	52.5
Public assembly	59.1	42.7

E. CONCLUSION

The goal of this task was to establish a general indication of the performance of USAF versus civilian fire departments. This chapter described the methodology used to statistically compare the performance of USAF and civilian fire departments. Results were presented for four property types: (1) All residential, (2) Office and store, (3) Storage, and (4) Public assembly. Distributions of estimated dollar loss, number of casualties and extent of flame and smoke damage from both the civilian (NFIRS) and the Air Force fire incident report databases were presented for each property type. The comparisons between civilian and Air Force data are quite consistent for all property types. However, there is not a clear overall consensus of better performance for either the Air Force or the civilian fire departments.

SECTION III
THE EFFECT OF USAF RESPONSE TIME ON FIRE LOSSES

A. PURPOSE

This analysis provides an assessment of the effects of fire department response time on the fire losses based on the USAF fire incident data. The goal is to determine the impact on the fire losses that will result from policy changes which alter the fire department response time to fire incidents.

B. PROPERTY TYPES INVOLVED

Fires incidents are recorded as involving fixed and/or mobile property. Fixed property includes all immobile structures (e.g., houses, office buildings) and outdoor property (fences, open land). Mobile property consists of aircraft, automobiles, water vessels, railroad vehicles and containers.

Fixed property falls into one of nine broad categories. Each of these categories are expanded into more detail. The nine main categories are the following:

(1) Public assembly property;
(2) Educational property;
(3) Institutional property;
(4) Residential property;
(5) Store and office property;
(6) Basic, industry, utility, and defence property;
(7) Manufacturing property;
(8) Storage property; and
(9) Miscellaneous.

The mobile properties can be classified as one of the following:

(1) Passenger road transport;
(2) Freight road transport;
(3) Rail transport;
(4) Water transport vessels;
(5) Air transport;
(6) Heavy equipment;
(7) Special vehicles and containers;
(8) Aircraft ground support equipment; and
(9) Miscellaneous.

Each of the nine mobile categories are subdivided into specific vehicle types.

Damage estimates include dollar value lost, casualties, and the extent of damage. The extent of damage incurred to a structure by flames and smoke was tabulated using the system explained in Section II, C, 5.

C. SELECTION OF RECORDS

The records used in the analysis were restricted to those with a fire in progress when the fire department arrived and which were extinguished by the fire department. Thus, false alarms and fire incidents that were controlled by means other than the fire department were eliminated.

In order to reduce the number of erroneous data records used in the analysis, SPSS was used to filter the database. SPSS is a statistical analysis program put out by SPSS, Inc. that allows various operations on database files. These operations involve record tagging logical record selections and renaming/removing records. Records that were discarded included those with a loss greater than the value, a dollar value containing 9's in all available fields (an implication that the actual value required a greater number of fields than available or that a correct value was not known), and those cases with the time of the alarm after the fire department arrival time. Duplicate records were also eliminated.

D. DISTRIBUTION OF CATEGORIES AND DATA IN THE INCIDENT DATABASE AMONG THE SELECTED RECORDS

1. Distribution of Categories in Database

The number of incidents corresponding to a particular category found in the database was used to determine if a category could be analyzed independently. Tables 3 and 4 show the event frequencies for all of the main divisions and some subdivisions for the fixed and mobile property uses.

TABLE 3. FREQUENCY OF EVENTS FOR FIXED PROPERTY USES

Category	Number of Incidents
All fixed	2952
Public assembly	141
Educational	44
Institutional	26
All residential	937
1 and 2 family dwellings	464
Stores and Offices	171
Industry, utility, and defense	161
Manufacturing	42
Storage	199
Miscellaneous	1231

TABLE 4. FREQUENCY OF EVENTS FOR MOBILE PROPERTY USES

Category	Frequency
All Mobile	1228
Passenger road transport	773
Freight Road Transport	150
Rail	6
Water Vessels	7
Air transportation	80
Fighters/attack aircraft	44
Heavy equipment	55
Miscellaneous	125
Aircraft ground support	32

2. Response Time Distribution

For all property occupancies, fixed and mobile, the records were filtered as in the previous section. About 3000 of the 8000 records were used. The distribution of the response times is shown in Figures 21 and 22. It is seen to be unevenly spread out over a 0- to 121-minute interval. Over 80 percent of the response times were between 1 and 4 minutes, and over 50 percent were between 2 and 3 minutes. For this analysis, all response times that were greater than 10 minutes (a total of 4.5 percent) were classified as ten or greater. Although not shown, distributions in smaller groups such as one- and two- family dwellings were similar to those shown in Figures 21 and 22. For categories with few incidents, the number of response times greater than 5 or 6 minutes is insignificant.

3. Distribution of the Total Dollar Loss

The total loss for each incident was divided into 50 ranges in order to reduce the number of significant digits. Losses less than 100 dollars were rounded to zero. The resulting frequency of the dollar losses are shown in Figure 23 for all fixed occupancies. The dollar loss is shown on a log scale due to the large range (0 to 8,000,000). To include all data, the zero losses were grouped with the 100 - 200 dollar losses. The graph shows that the majority of all the property losses fall below 10,000 dollar loss, with about 50 percent falling below $1000. It was found that this distribution was characteristic of any category, with roughly the same proportion over the same dollar values.

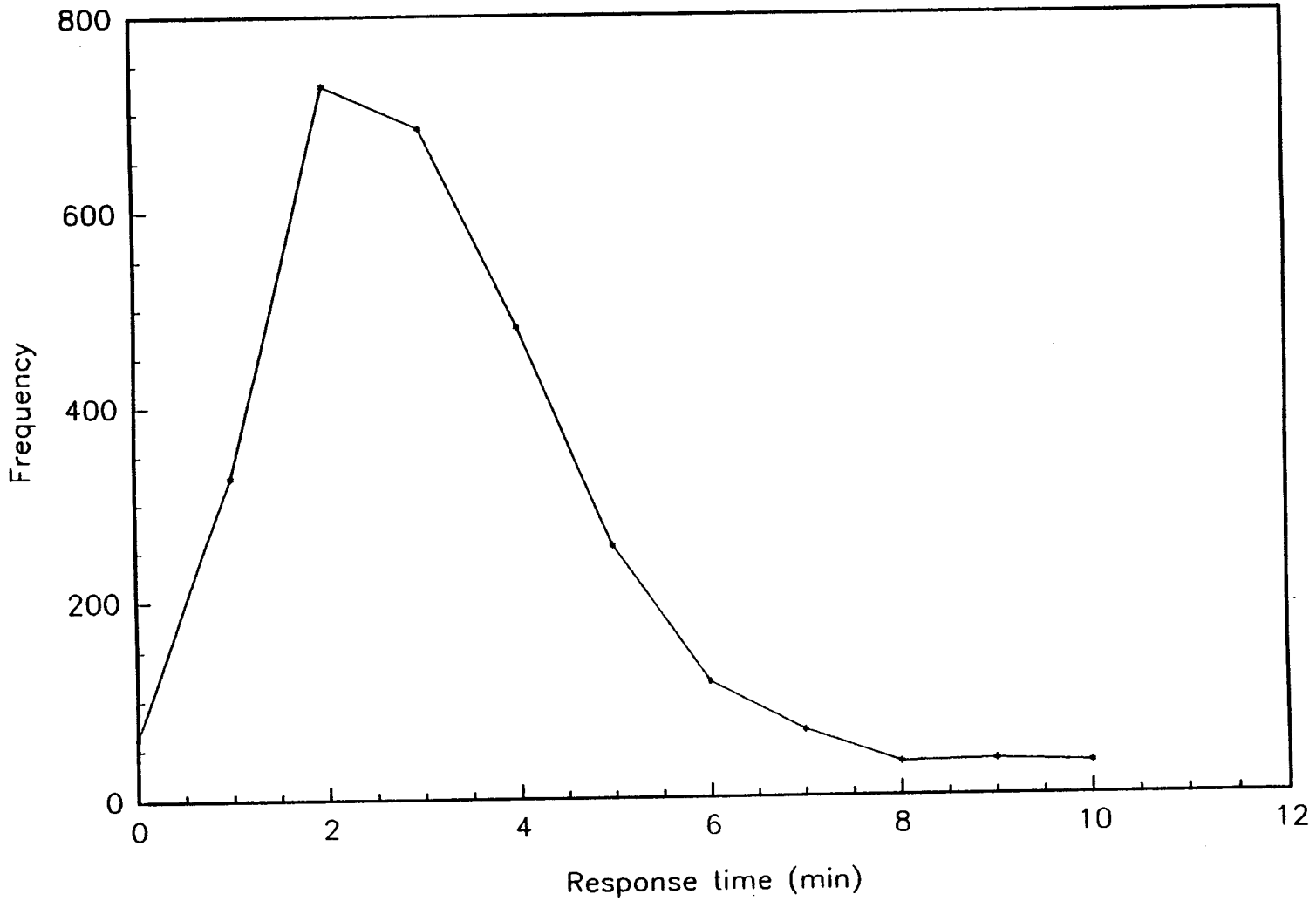


Figure 21. Distribution of Response Times

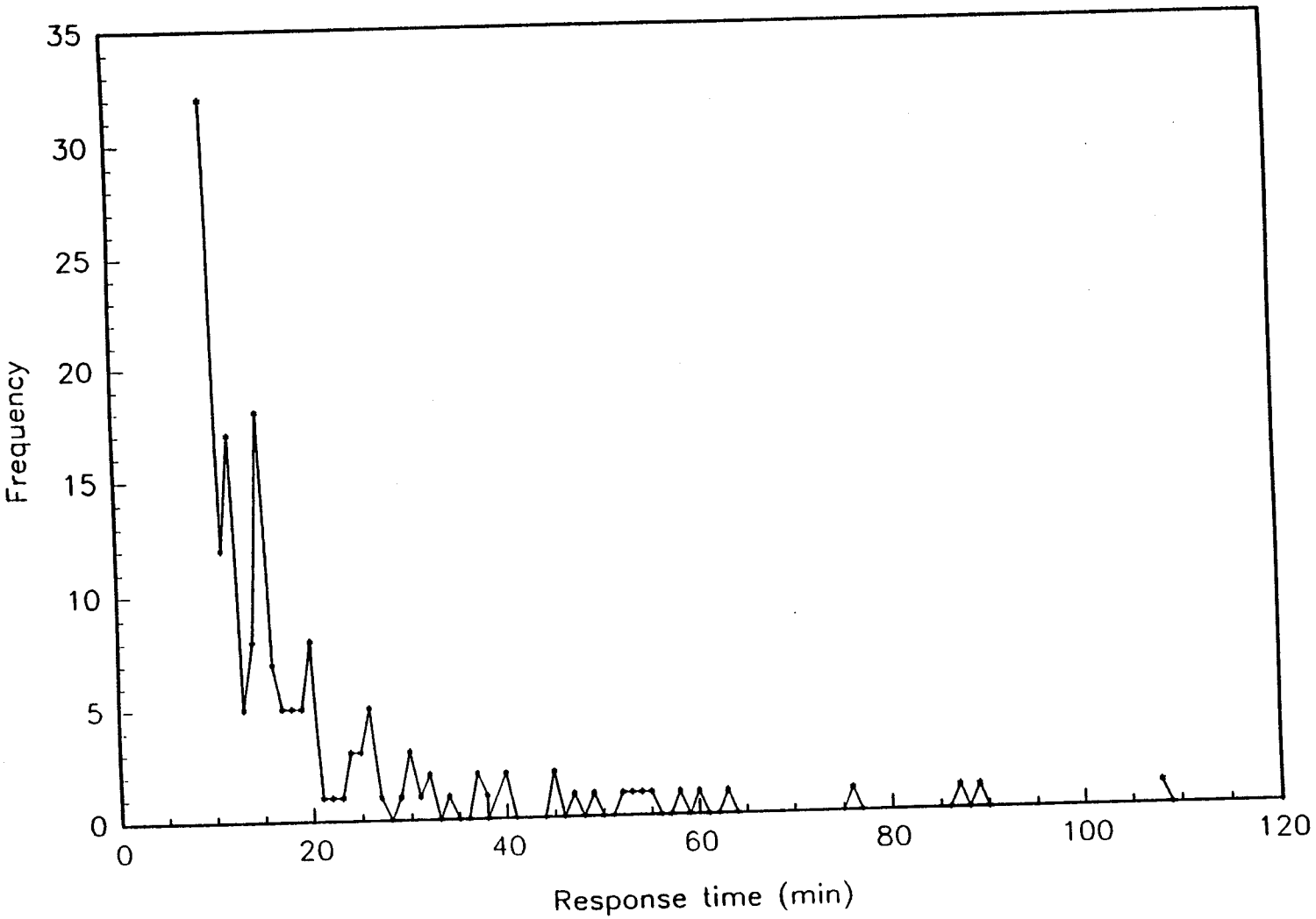


Figure 22. Distribution of Response Times

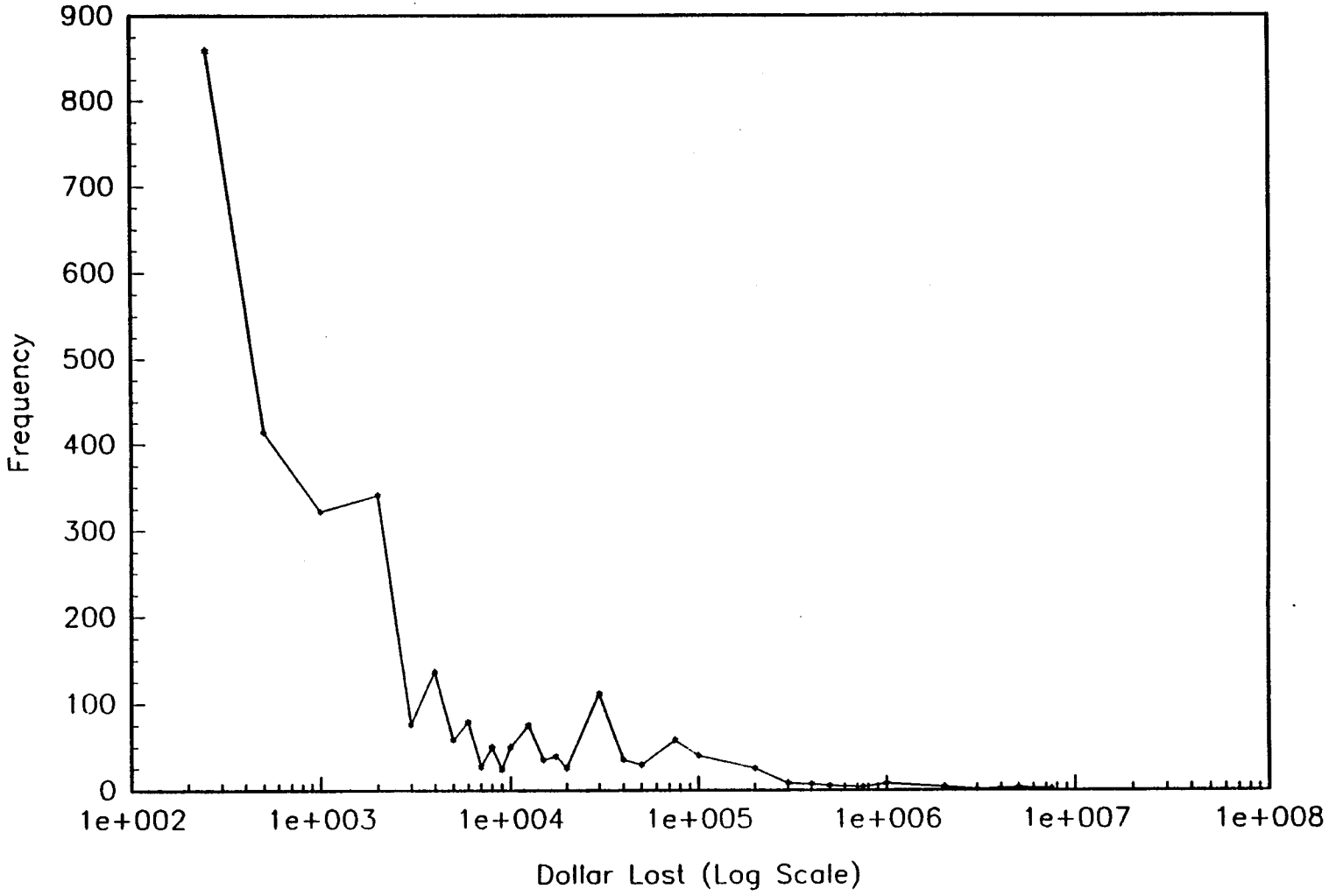


Figure 23. Frequency of Dollars Lost Total for All Fixed Occupancies

The log of the total dollars lost was found to have an approximate normal distribution for a single response time interval. Figures 24 through 26 show several distributions at the two minute response time interval for several categories. For the transformed curves, the zero loss values were not included.

4. Distribution of the Percent Dollar Loss

The percent loss distribution has a bimodal shape. This is due to the large number of incidents that accumulate at the 0 and 100 percent boundaries. Figure 27 shows typical frequency curves for various categories. This characteristic shape is indicative of the fact that as the extent of fire damages increases, it is more difficult to limit further spread.

5. Distribution of the Extent of Fire and Smoke Damage

The distribution of the extent of smoke and fire damage also tended to be bimodal. Figure 28 shows the frequency curves for all fixed dwellings. Excluded from these curves are incidents that had a value of 8 (not a structure fire). The incidents with a value of 9 (no damage) were relabeled 0, so that the result was a range from 0 to 7 of increasing damage. As a result, about 40 percent of the fixed dwelling fire incidents were not included. The graphs indicate that it is most likely for a structure to receive a fire extent rating of 2 (damage confined to part of room of origin) and the most likely smoke extent was 6 (damage confined to building of origin).

6. Distribution of the Number of Casualties

The shape of the casualty distribution was similar to the total dollars lost. Figure 29 shows the frequency of an incident with a particular number of casualties for all fixed occupancies (excludes only incidents with just mobile property). Only 200 incidents had at least one casualty. There were no applicable incidents with over ten casualties.

E. ANALYSIS OF RESPONSE TIME VERSUS DAMAGE

1. Method of Analysis

The Air Force database was analyzed using the SPSS statistical analysis computer package. The program was used to compute the mean loss of the following categories for a particular response time:

(1) Total property value lost;
(2) Percent of property and content value loss;
(3) Extent of fire and smoke spread; and
(4) Number of casualties.

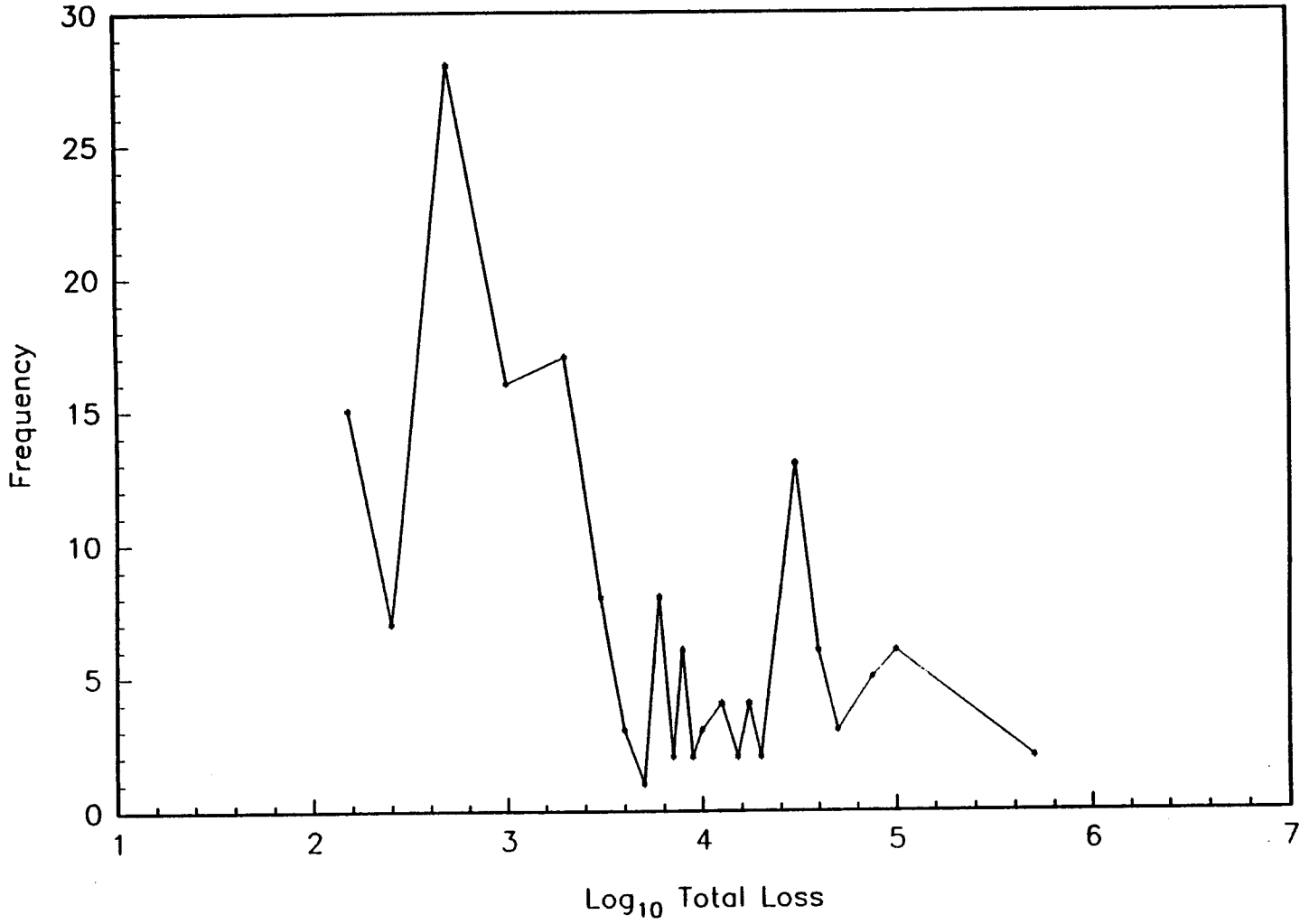


Figure 24. All Fixed Occupancies, 2-minute Response Time

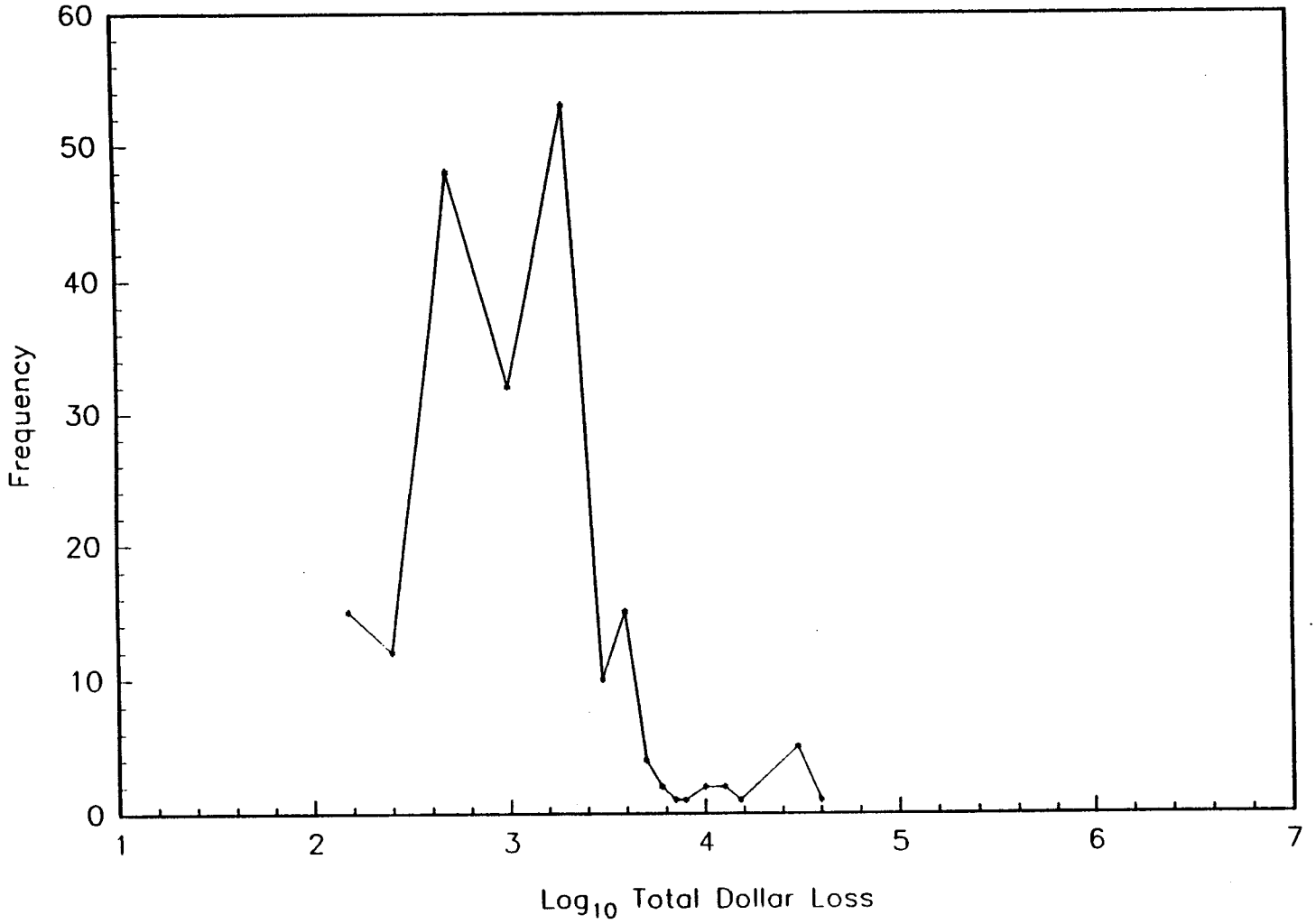


Figure 25. All Residential Occupancies, 2-minute Response Time

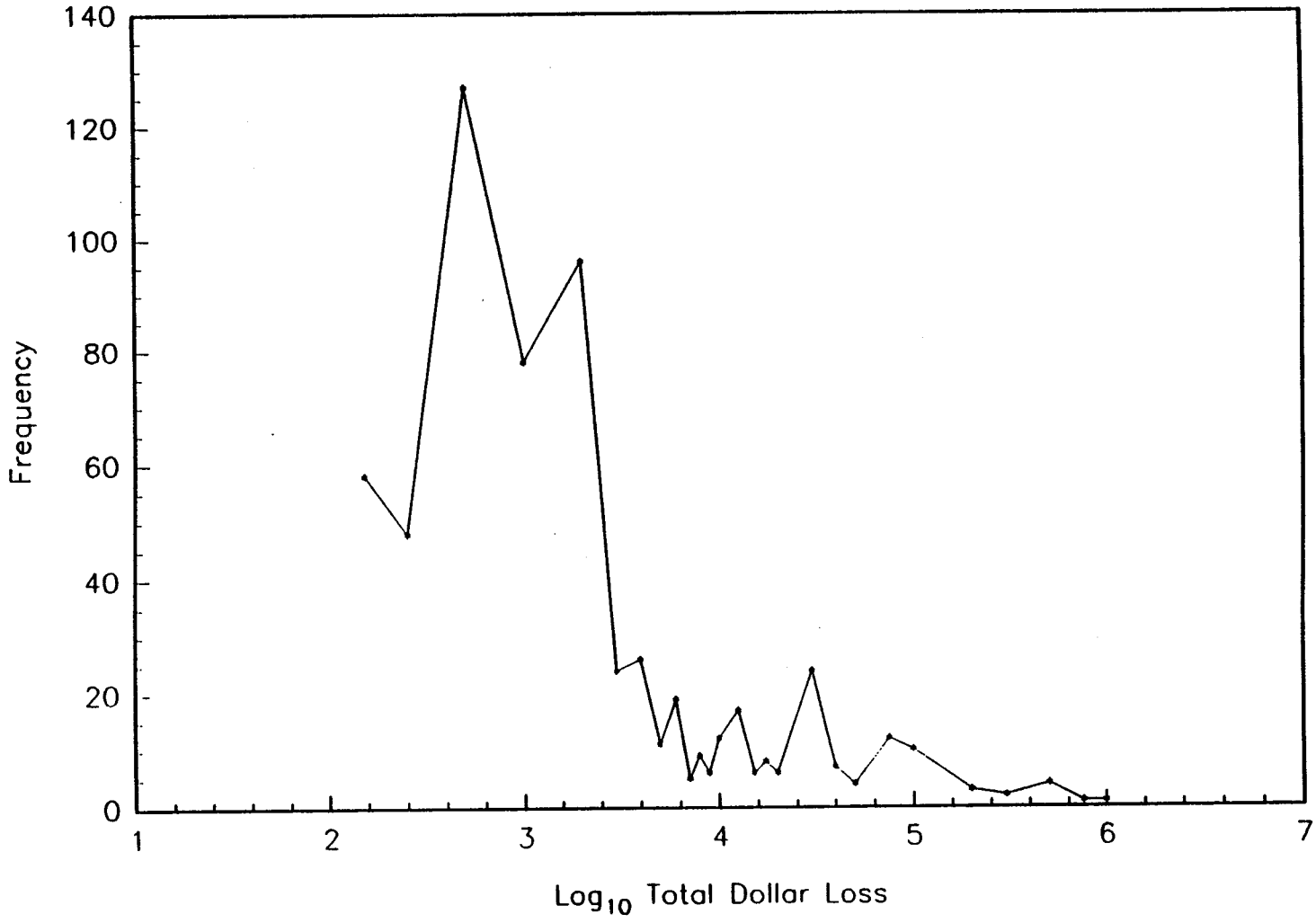


Figure 26. All Passenger Road Transport Vehicles, 2-minute Response Time

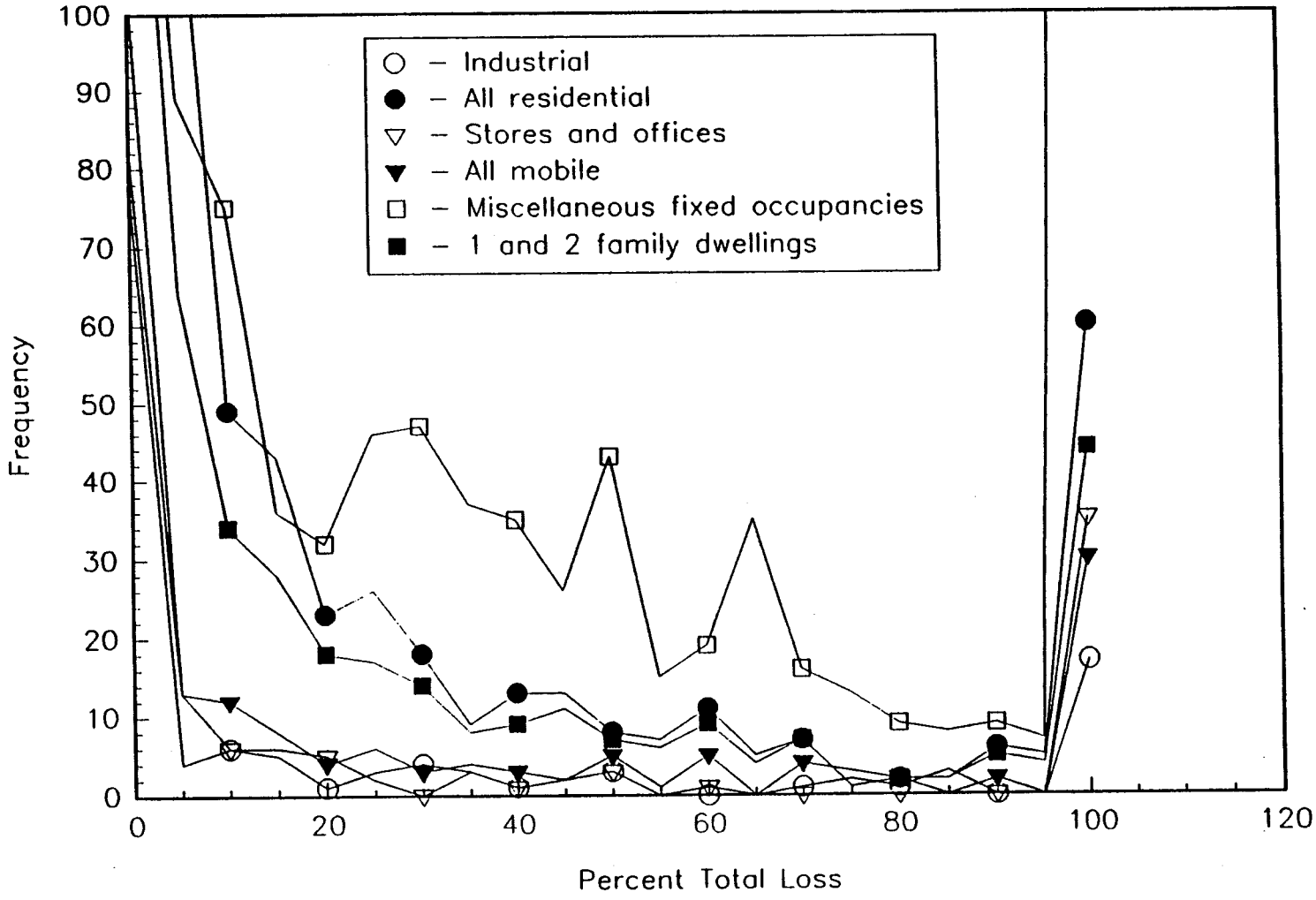


Figure 27. Frequency of Percent Loss for Various Categories

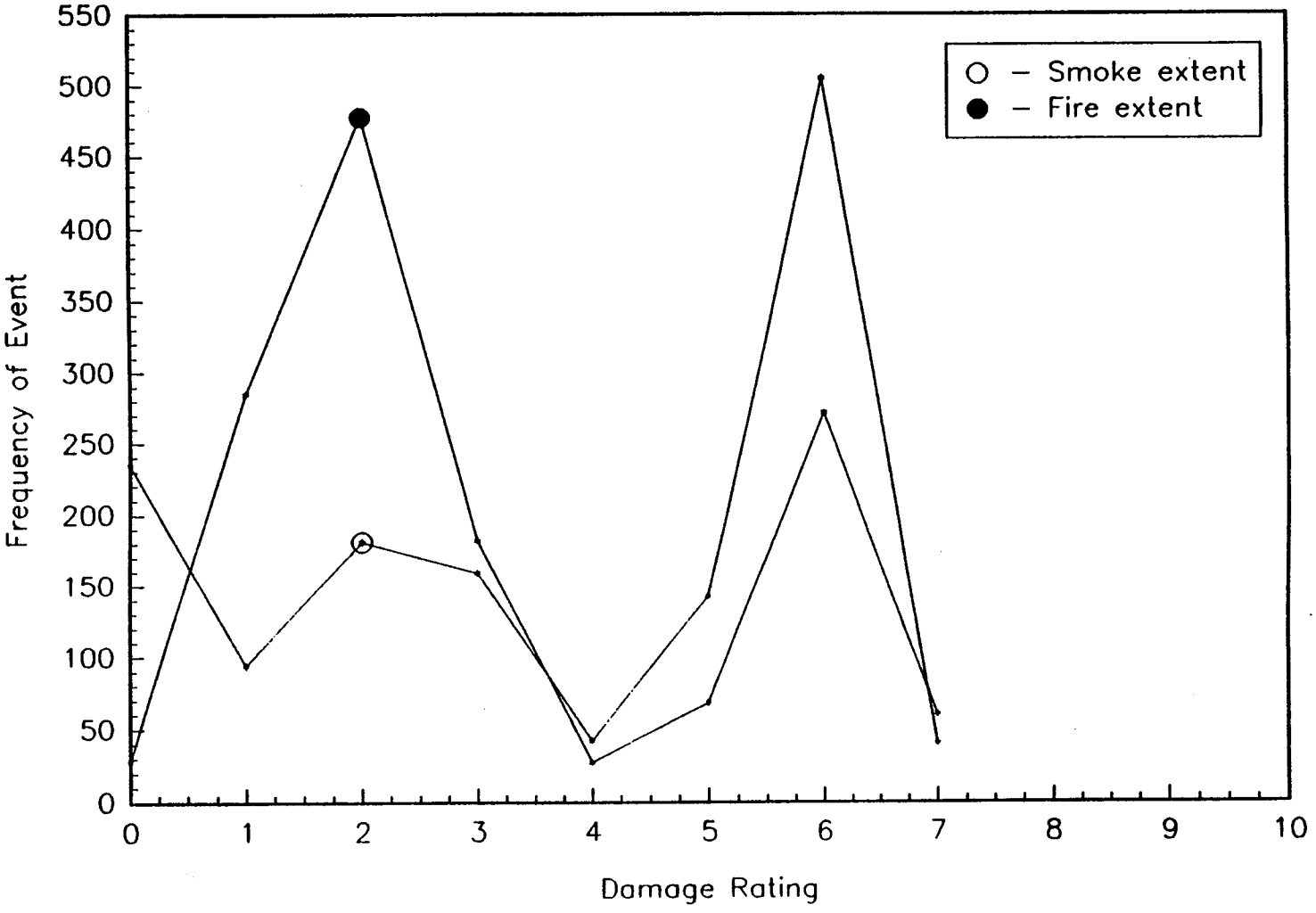


Figure 28. Distribution of Smoke and Fire Damage

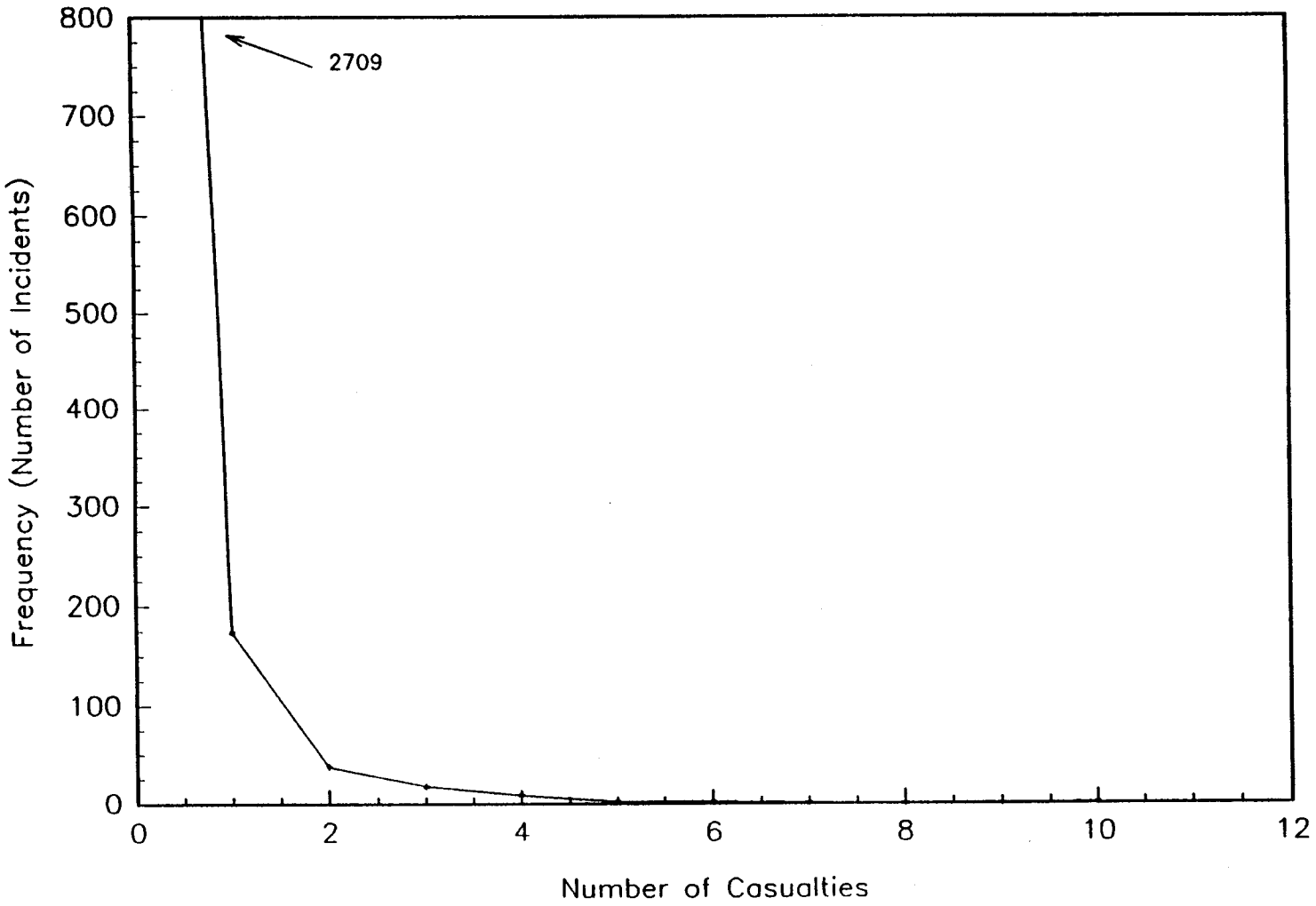


Figure 29. Frequency of Events with Casualties

The net result was a curve showing the average incident value loss/smoke spread/casualties as a function of response time and occupancy. The statistical operations required a logarithmic transformation of the total incident dollar loss. Thus, values with a zero loss could not be included in the analysis correlating dollar loss to response time. Instead, the probability that an event will have a zero loss was determined as a function of the response time. This value can be used in conjunction with the average dollar loss per non-zero loss event to determine the expected event loss.

The Air Force data were divided into seven categories. Since the total property loss was approximately log normal, the 95 percent confidence intervals were calculated for the total property loss using standard statistical methods. For bimodal distributions, these methods are not valid and relative methods described in Appendix B must be used. A 95 percent confidence interval relative to another mean value was calculated for the percent loss total loss, the extent of fire and smoke damage, and the number of casualties. A relative 95 percent confidence interval compares a mean value calculated with a small number of incidents to a mean value calculated with a large number of incidents. The confidence intervals present a range of possible values for accuracy estimations.

Further analysis was performed to estimated the dollar loss associated with adding or removing fire stations. Details of this procedure may be found in Appendix C.

2. Selection of Categories

As a result of the sharply uneven distribution of the response times, it was determined that over 150 incidents were necessary to perform an analysis of the effect on response time with the loss. This was found by analyzing several categories with various numbers of incidents. A category with 150 incidents could expect only 15 incidents between a 6- and 10-minute response time, or three incidents per minute. With such few incidents on a time interval, little information could be obtained for correlating the response time to a loss. Results indicate that even 170 incidents was too few.

Although it was desirable to group the categories in homogeneous groups (as specific of an occupancy grouping as possible), many categories had far less than 150 incidents (Table 3). The following categories were analyzed:

(1) All fixed property - 2952 incidents;
(2) Miscellaneous fixed property - 1231 incidents;
(3) All residential - 937 incidents;
(4) Passenger road transport - 773 incidents;
(5) One- and two-family dwellings - 464 incidents;
(6) Store and office - 171 incidents; and
(7) Industrial and manufacturing - 161 incidents.

F. RESULTS

1. Correlation of the Total Dollar Loss to the Response Time

The total dollar loss was analyzed for the following categories:

(1) All fixed dwellings,
(2) All residential dwellings,
(3) All one- and two-family dwellings,
(4) Store and office occupancies,
(5) Industrial and defence occupancies,
(6) Miscellaneous fixed property and special property, and
(7) Passenger road transport vehicles.

Incidents that had a zero loss were not included in the mean value versus response time analysis because the data was transformed with a logarithmic function. In order to incorporate the zero loss data, the probability of an event having a zero loss is shown in Table 5 as a function of the response time.

TABLE 5. PROBABILITY OF A ZERO-LOSS INCIDENT FOR ALL FIXED OCCUPANCIES

Response time (minutes)	Probability	Response time (minutes)	Probability
0	0.49	6	0.33
1	0.46	7	0.31
2	0.44	8	0.28
3	0.42	9	0.25
4	0.38	10	0.23
5	0.36		

The data in Table 5 are the result of a liner curve fit for the percent of incidents with a zero loss. The raw data and the curve fit are shown in Figure 30.

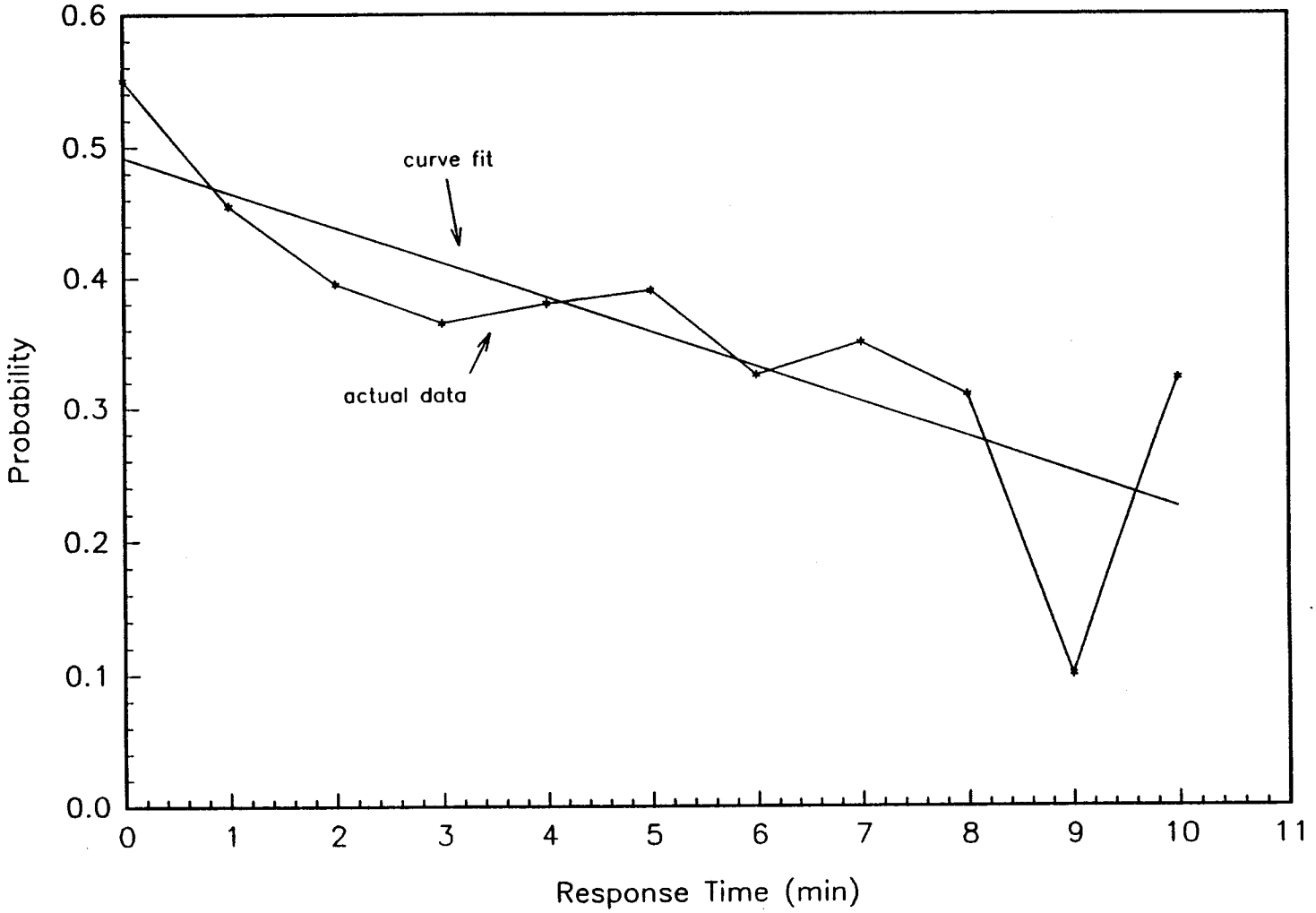


Figure 30. Probability for Any Fixed Occupancies to have an Incident with a $0.0 Loss

The average dollar loss as a function of the response time is plotted in Figures 31-37. Linear curve fits were generated for five of the occupancies in shown in Figures 31-37 in form of:

$$DL = a + b \cdot RT$$

where DL is the dollar loss, a and b are the curve fit parameters for the specific occupancy, and RT is the response time. The values of a and b as well as the response time valid range are shown in Table 6 for the five occupancies.

TABLE 6. CURVE FIT PARAMETERS FOR DOLLAR LOSS

Occupancy	a (dollars)	b (dollars/min)	Range (min)
All Fixed	1402	503	0-7
All Residential	1995	553	0-6
1&2 Family	3522	708	0-6
Miscellaneous Fixed Property	1215	180	0-7
Passenger Vehicles	1256	188	0-8

The probability of this loss occurring is the complement of the probability of a zero loss. The figures show that there is an increase in the total dollar loss of 20 - 80 percent for all fixed property, all residential, and the passenger road transport vehicles. The four remaining categories are inconclusive. It can also be observed that the number of incidents in the store and industrial (171 and 161 respectively) were too few to give any indication of the correlation between dollar loss and the response time, especially after five minutes. In all cases the data between 6 and 10 minutes cannot be used to support any hypothesis. This is due to an insufficient number of incidents at these response time intervals.

2. Correlation between the Percent Property Loss and the Response Time

The percent property loss versus the response time was analyzed for the same categories as the total dollar loss. The mean value as a function of the response time is shown in Figures 38-44. All residential dwellings, all fixed property, one- and two-family dwellings, miscellaneous fixed property, and passenger road transport vehicles show a large increase in the percent loss between the 0- and 4-minute response times. After 4 minutes, the categories are inconclusive due to too few events. As with the total dollar loss, the store and office occupancies and industrial occupancies reveal a large shortage of data.

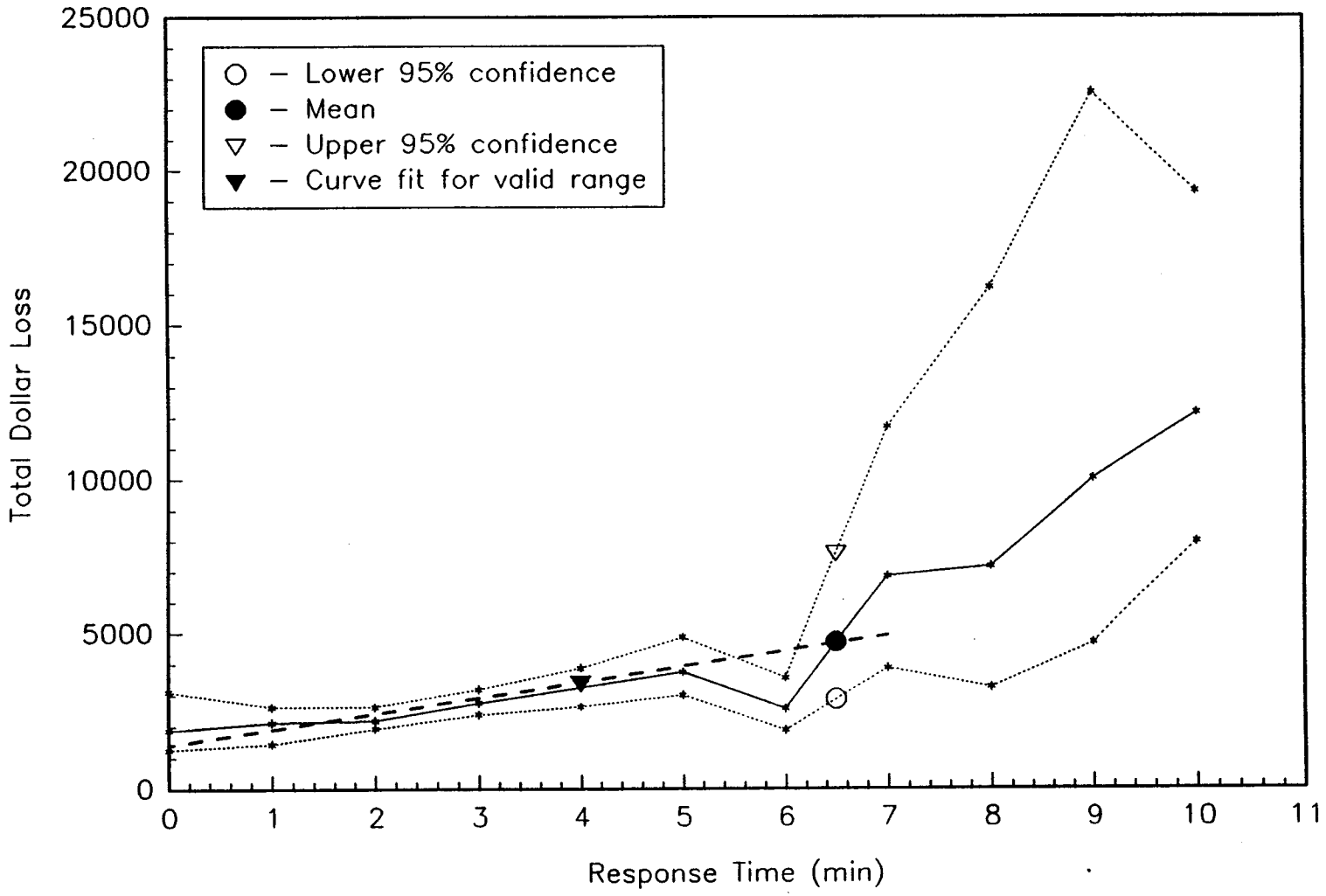


Figure 31. Mean Total Dollar Loss for All Fixed Occupancies

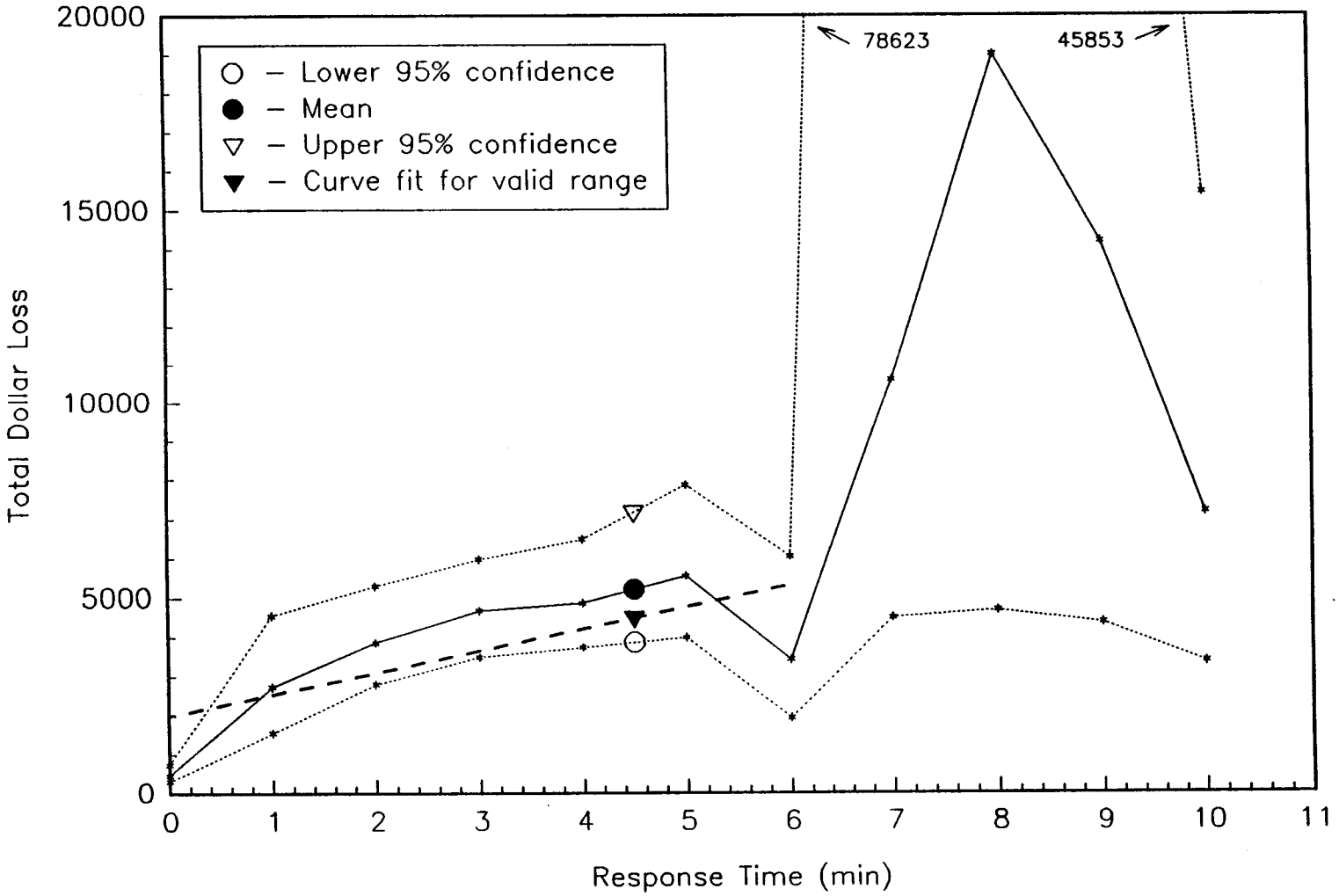


Figure 32. Mean Total Dollar Loss for All Residential Properties

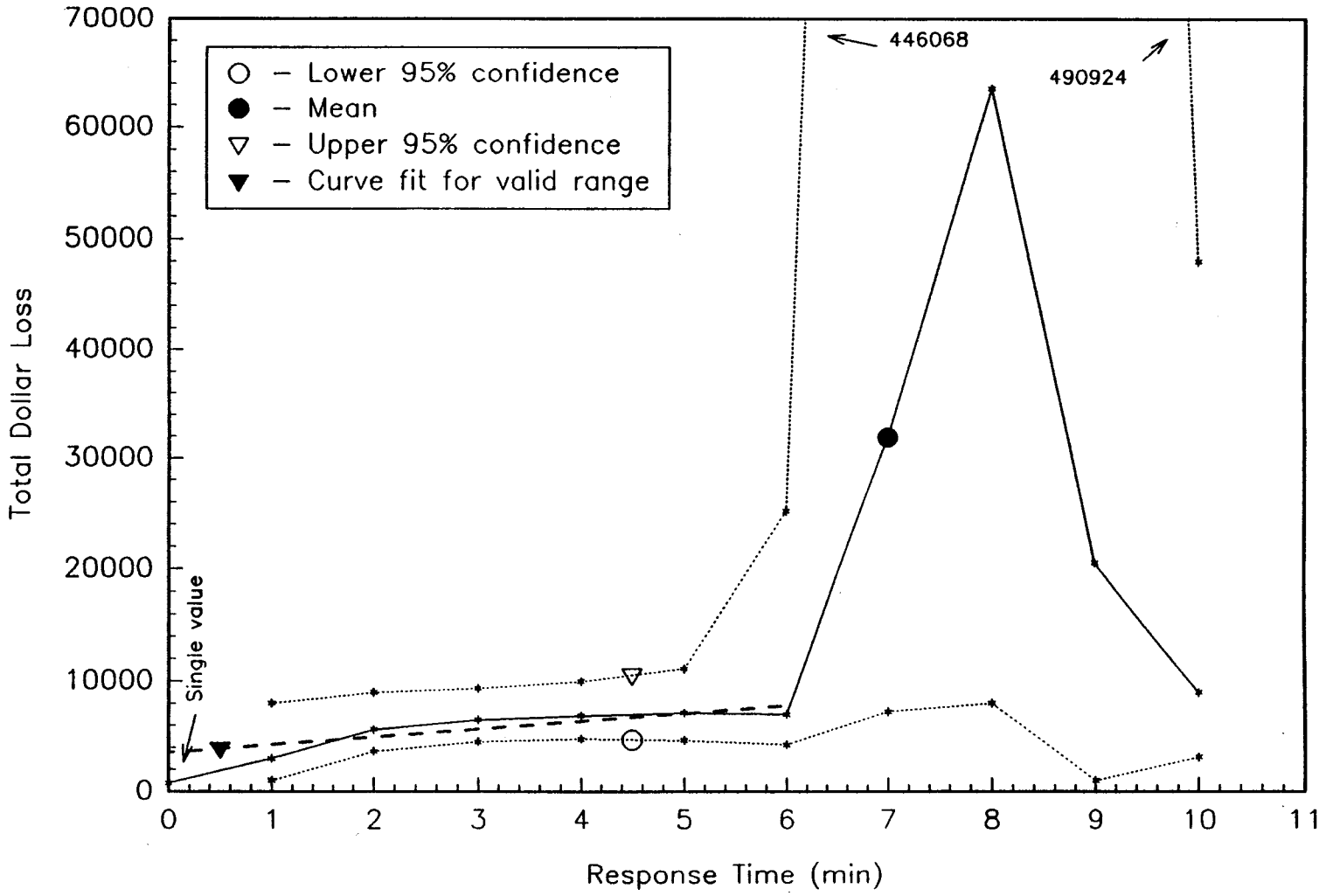


Figure 33. Mean Total Dollar Loss for All One- and Two-family Dwellings

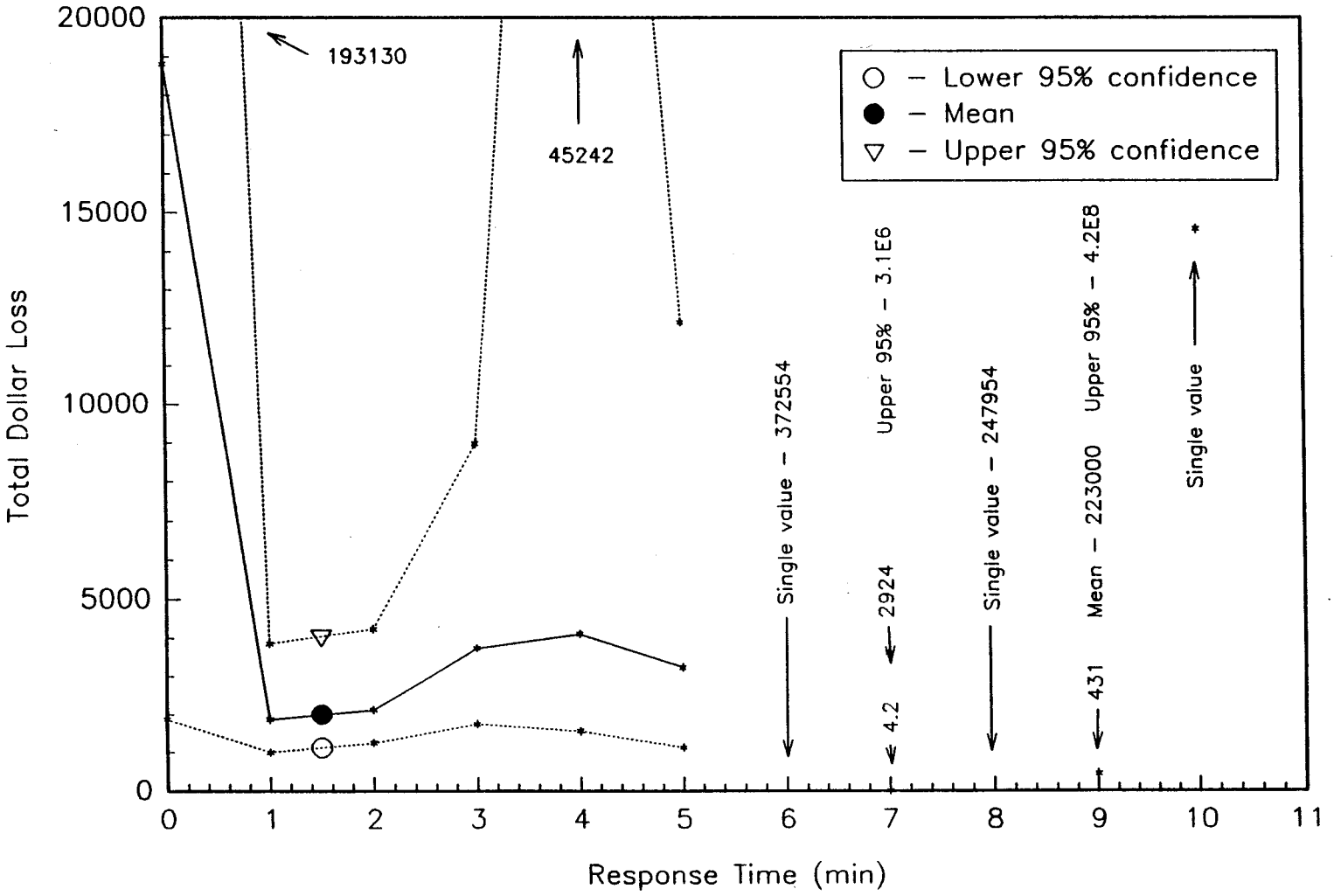


Figure 34. Mean Total Dollar Loss for Store and Office Occupancies

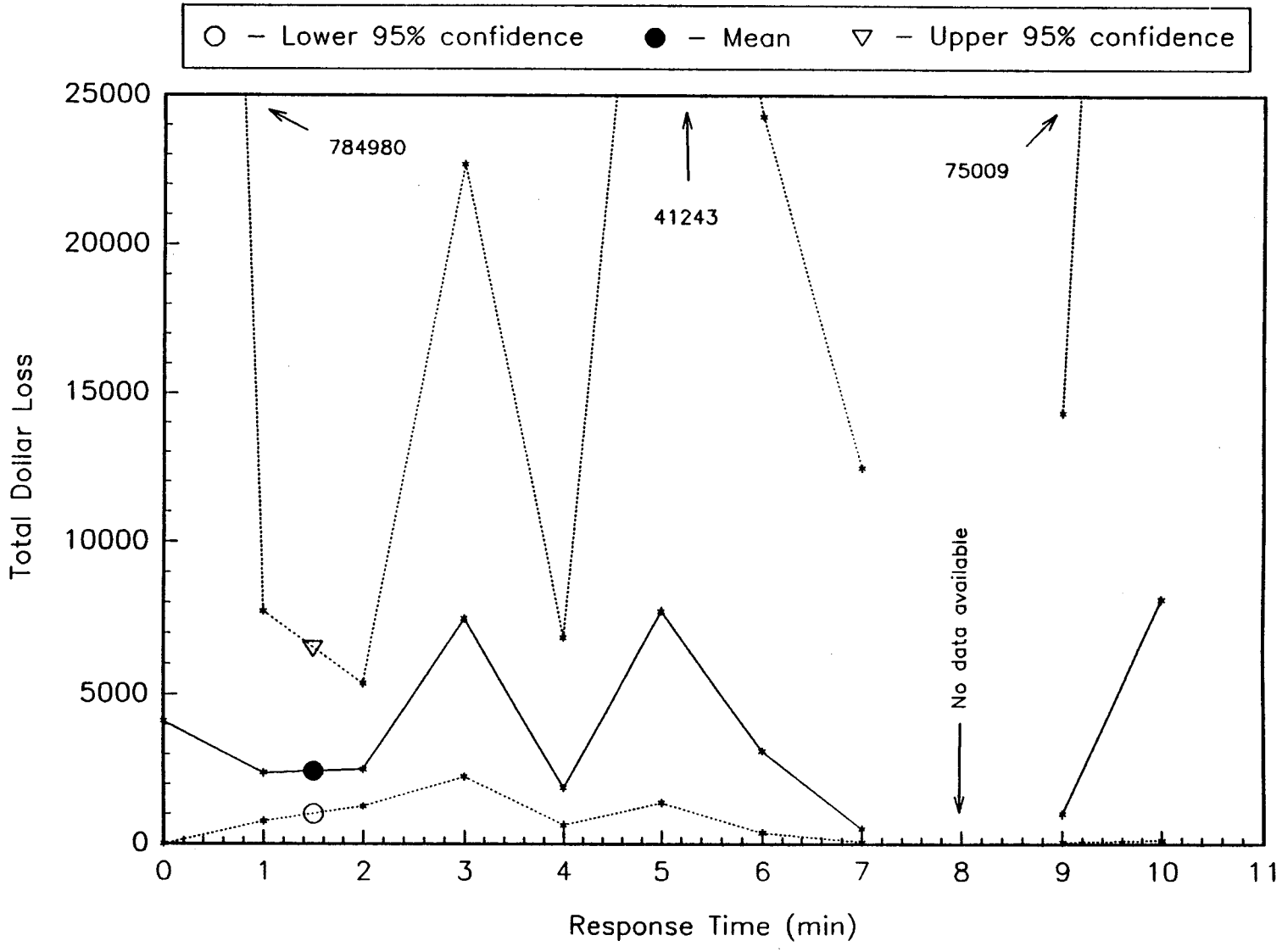


Figure 35. Mean Total Dollar Loss for Industrial Occupancies

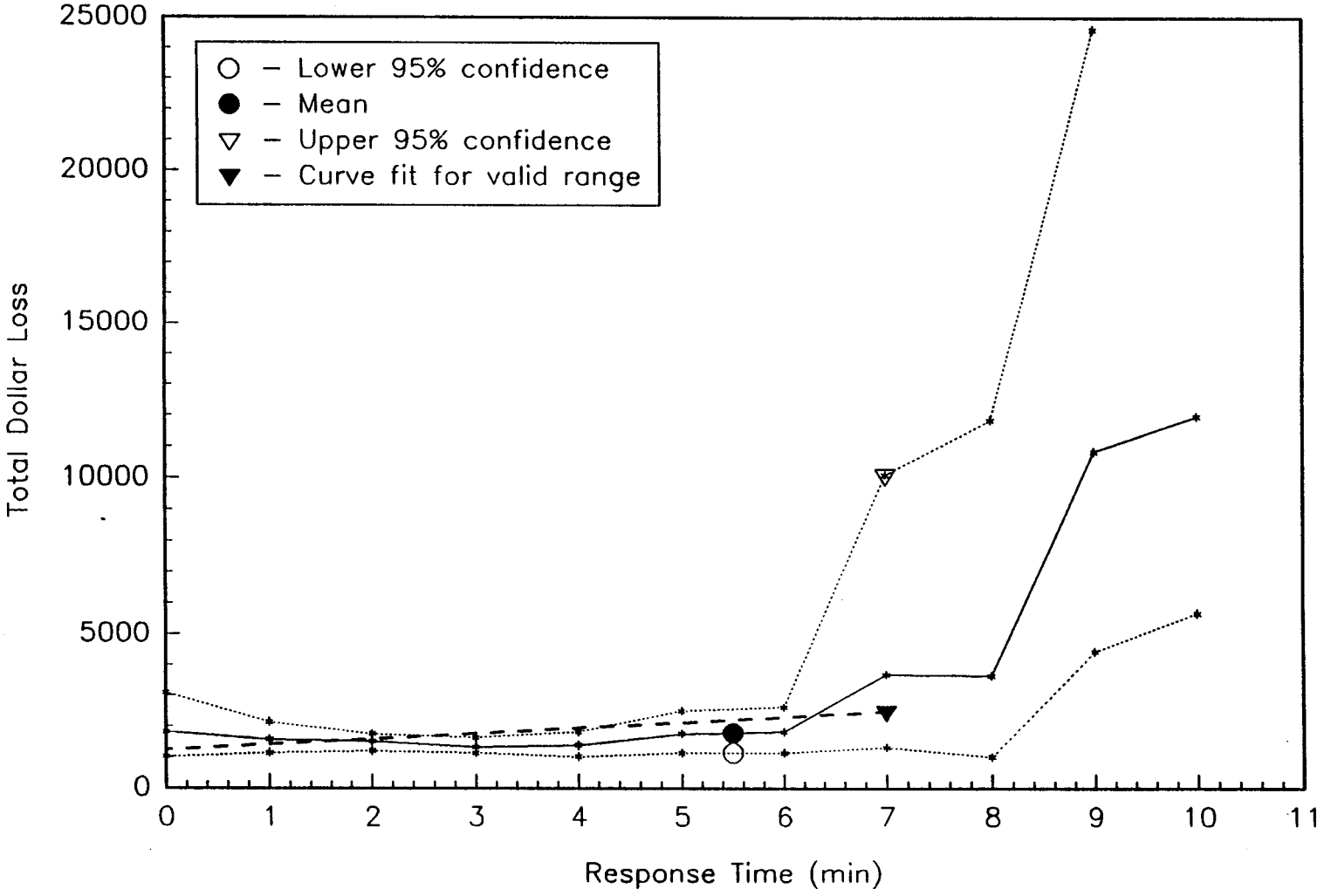


Figure 36. Mean Total Dollar Loss for Miscellaneous Fixed Occupancies

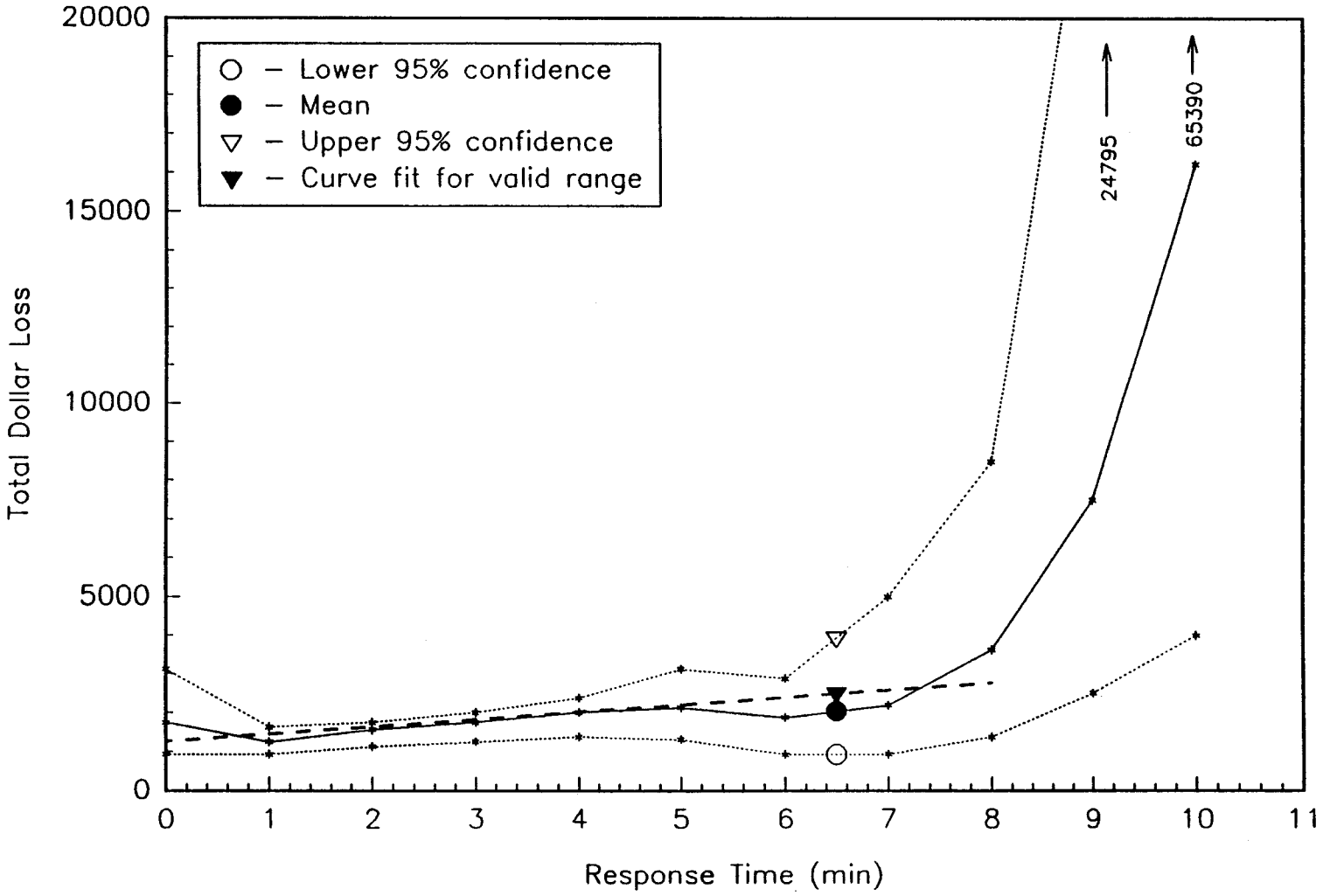


Figure 37. Mean Total Dollar Loss for Mobile Property

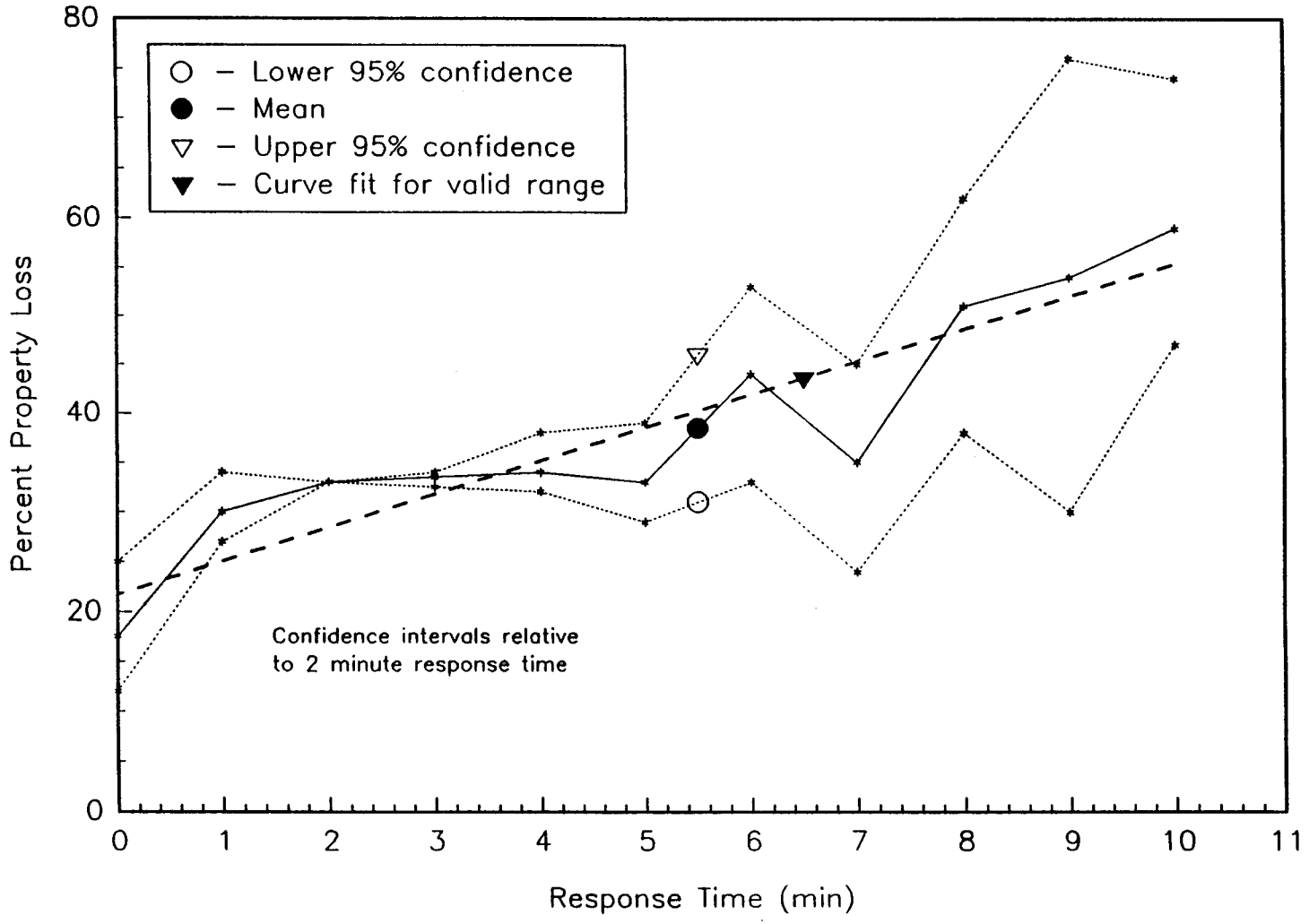


Figure 38. Mean Percent Total Loss for All Fixed Occupancies

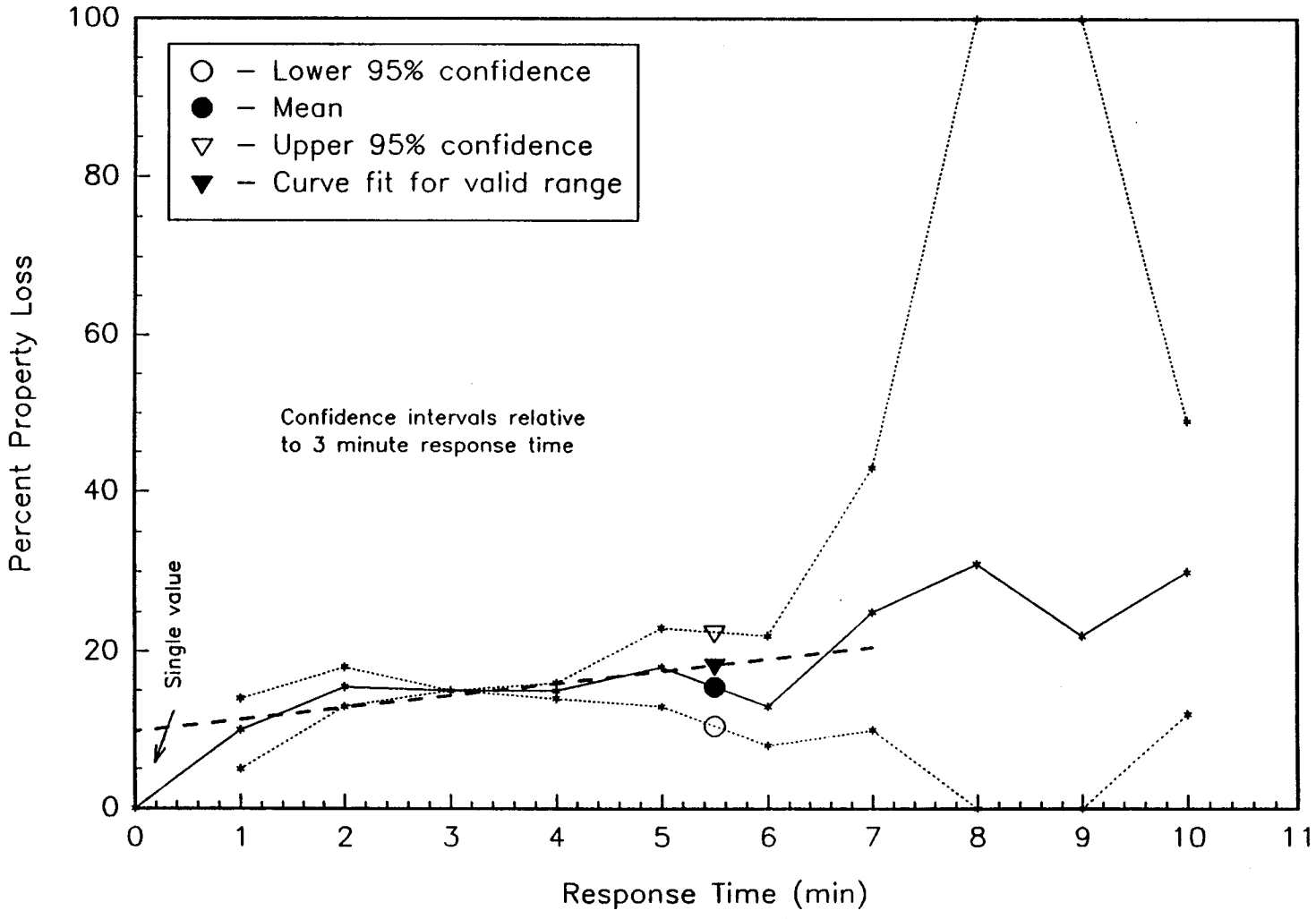


Figure 39. Mean Percent Total Loss for All Residential Dwellings

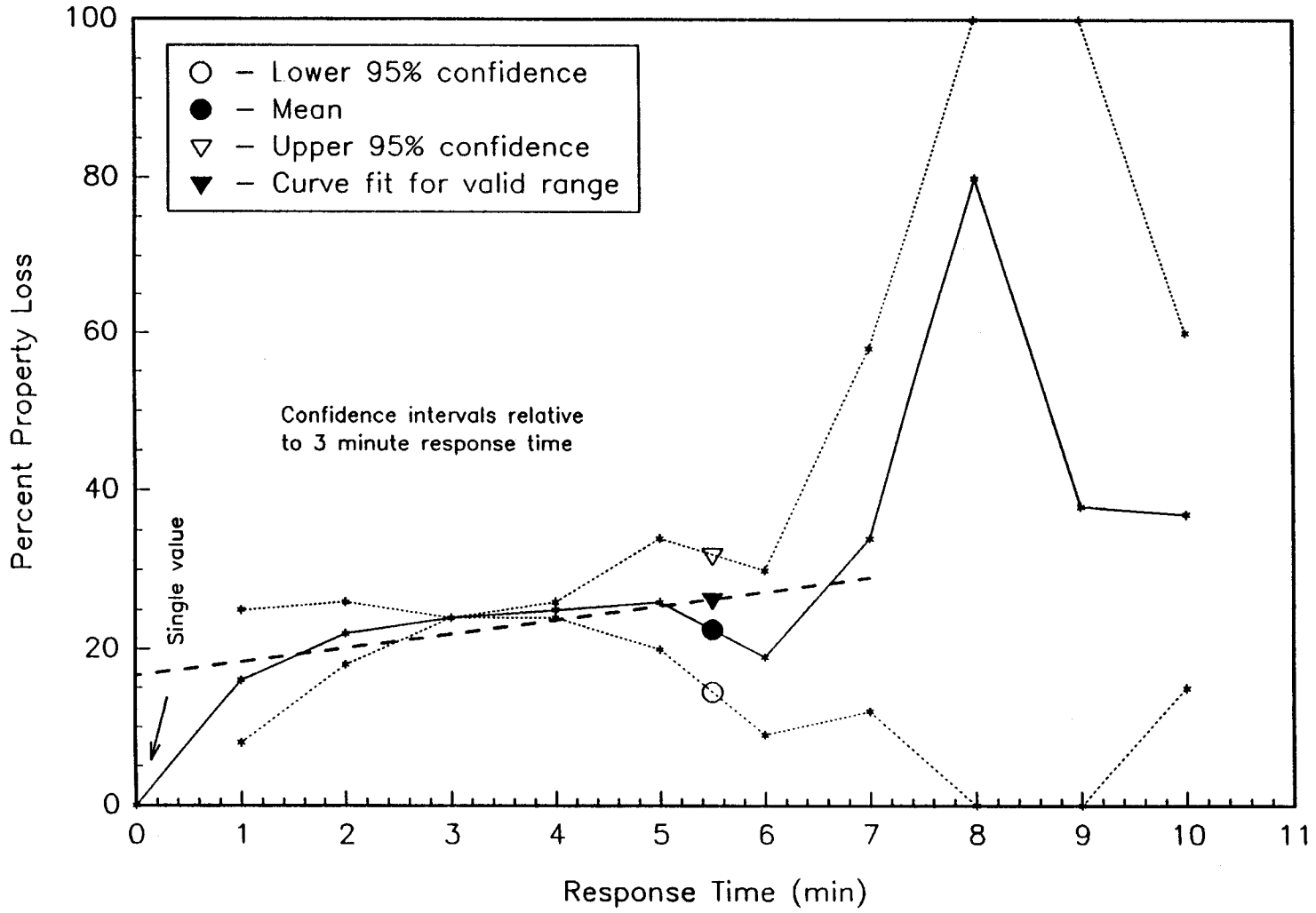


Figure 40. Mean Percent Total Loss for One- and Two-family Dwellings

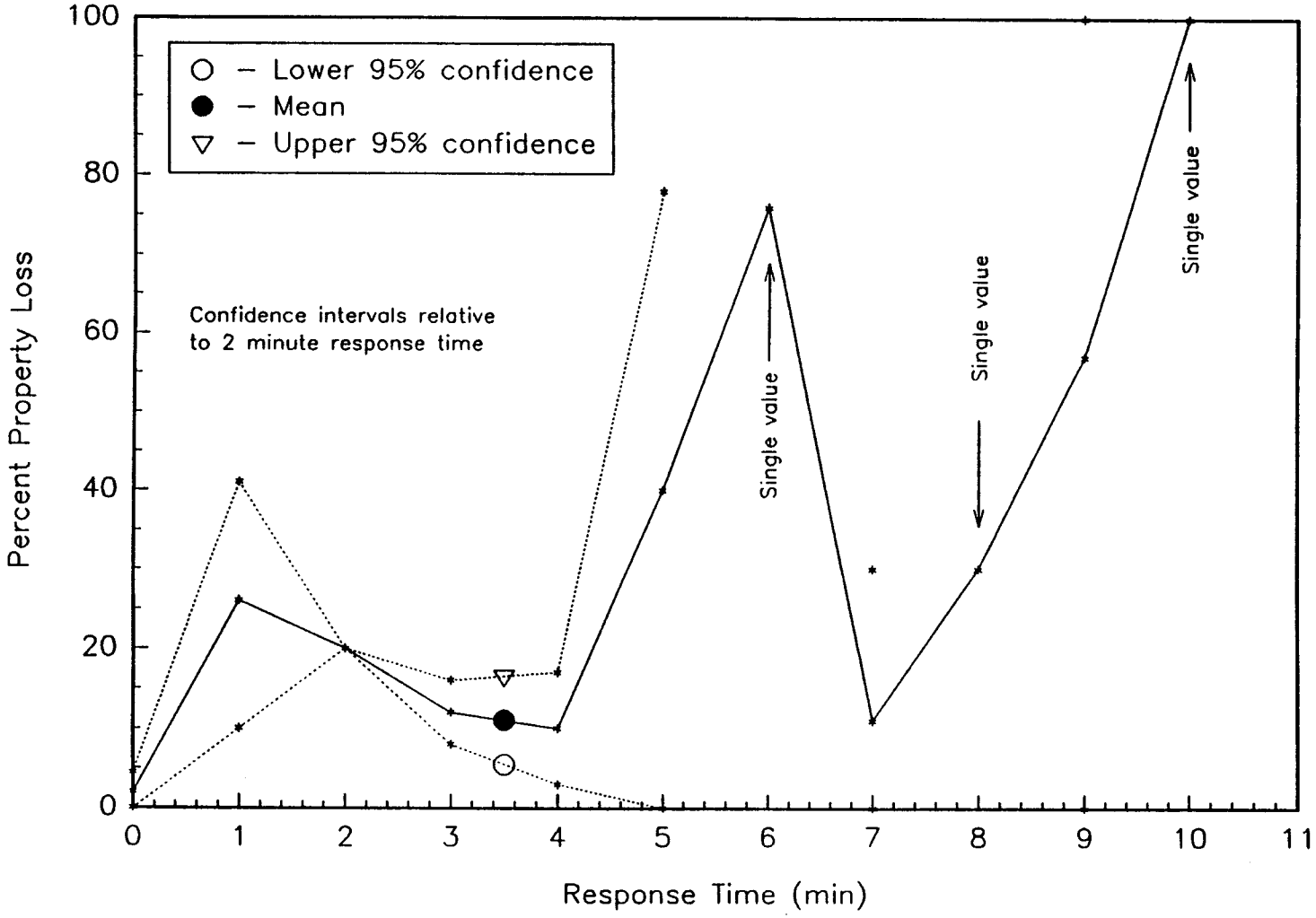


Figure 41. Mean Percent Total Loss for Store and Office Occupancies

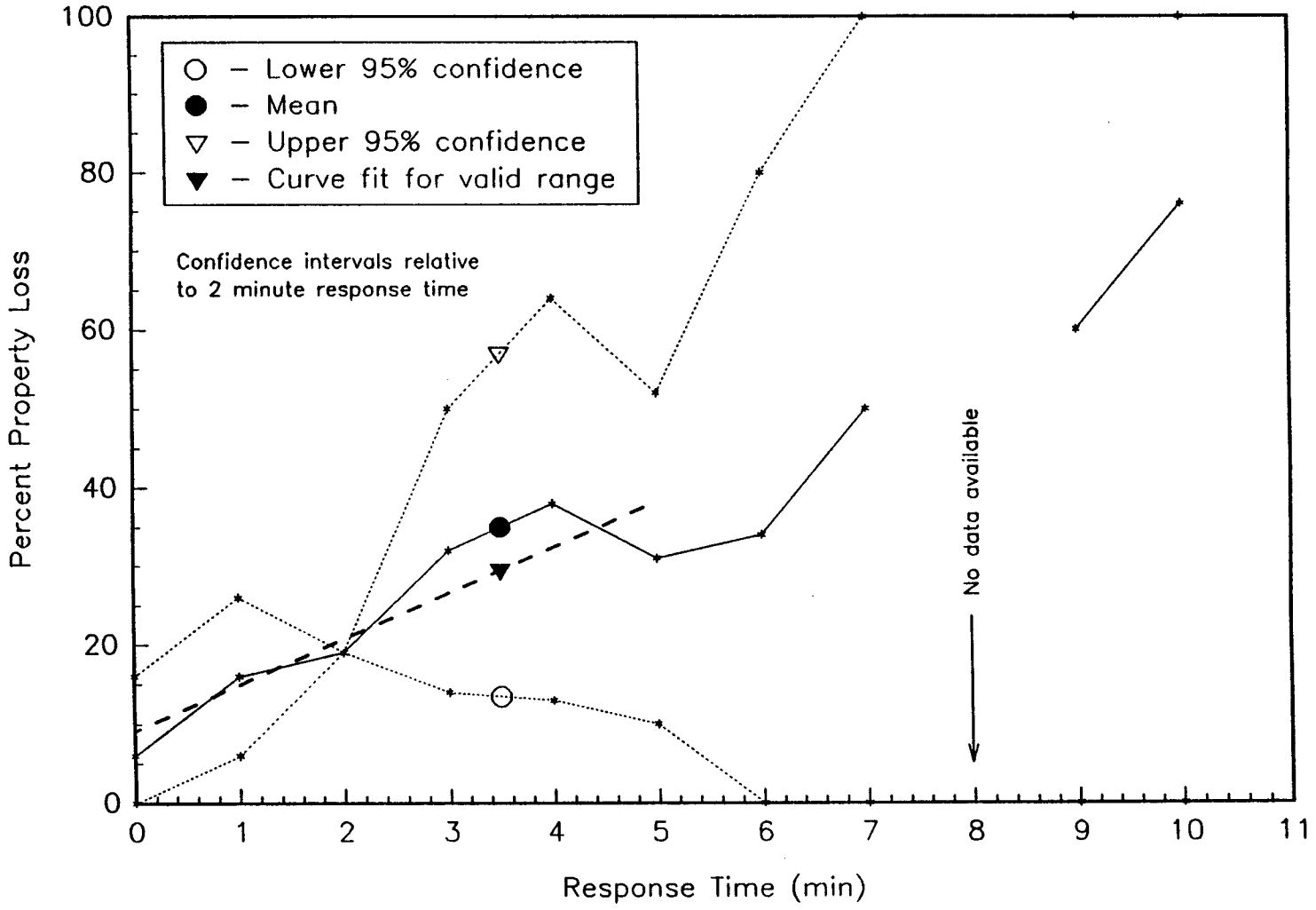


Figure 42. Mean Percent Total Loss for Industrial Occupancies

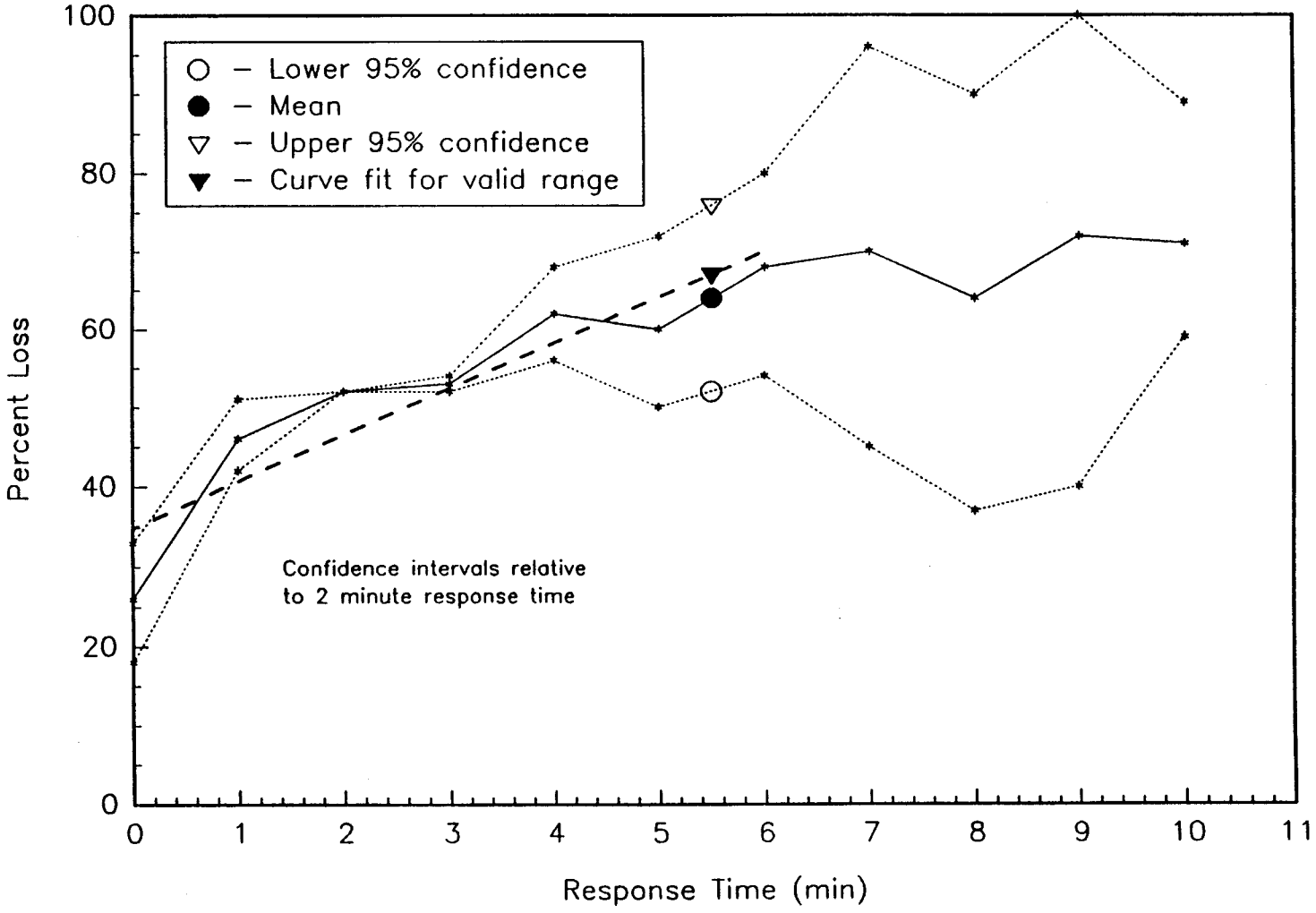


Figure 43. Mean Percent Total Loss for Miscellaneous Fixed Property

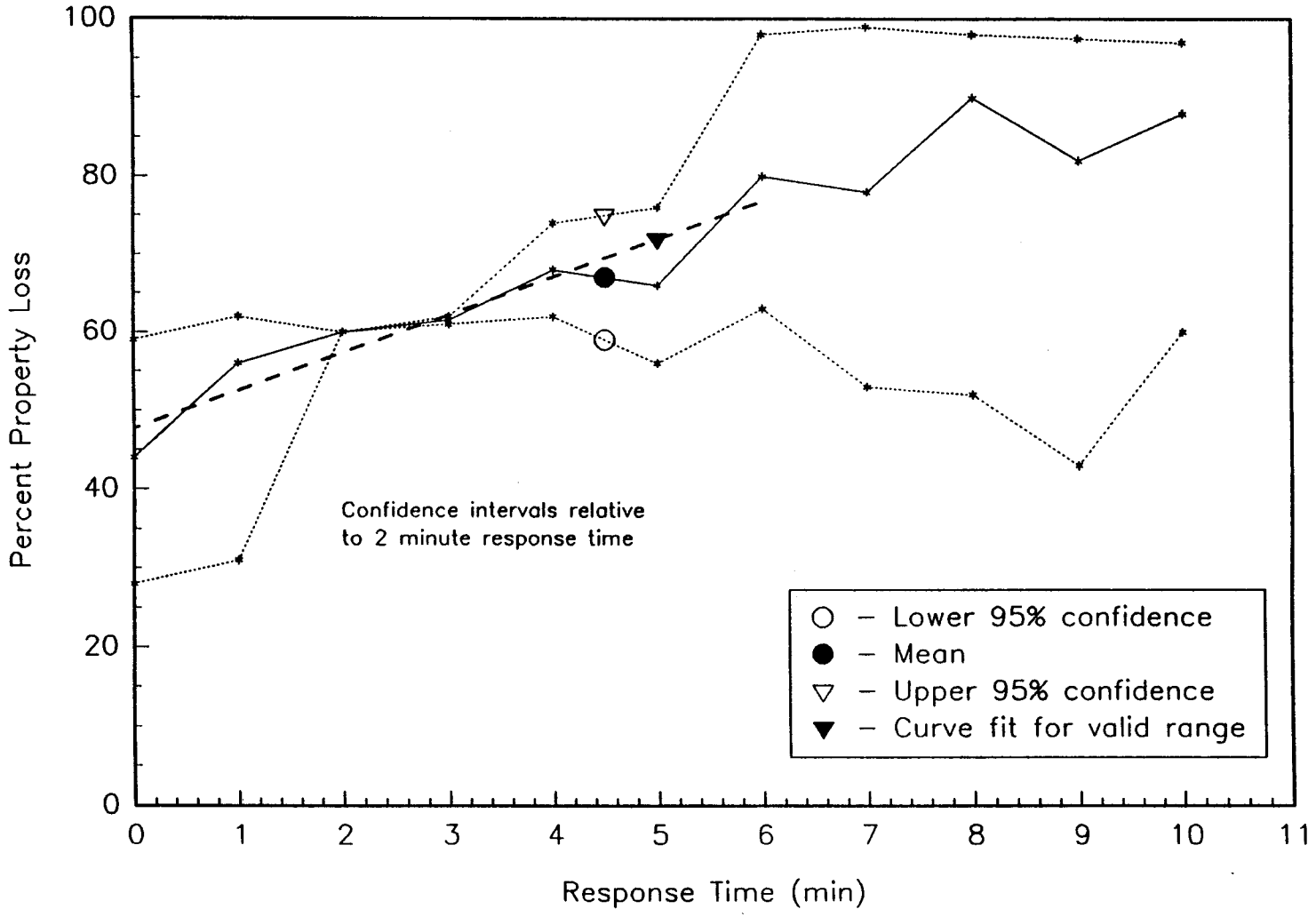


Figure 44. Mean Total Percent Loss for Passenger Road Transport

It was shown that the percent loss is bimodal due to the accumulation of 0 and 100 percent values. The general increase in the percent loss values is likely due to a shift in the number of 0 and 100 percent values. Figure 45 shows the percent of 0 percent values and the percent of 100 percent loss values for all fixed dwellings. The total percentage of these values is approximately constant at 65 percent. However, there is a marked shift toward the 100 percent loss as the response time increases. Six of the percent loss curves were linearly fit as in Section III, F. The values for a and b are shown in Table 7.

TABLE 7. CURVE FIT PARAMETERS FOR PERCENT LOSS

Occupancy	a (percent)	b (percent/min)	Range (min)
All Fixed	21.7	3.37	0-10
All Residential	9.8	1.53	0-7
1&2 Family	16.6	1.79	0-7
Industrial	9.1	5.83	0-5
Miscellaneous Fixed Occupancies	34.9	5.86	0-6
Passenger Vehicles	47.6	4.86	0-6

3. Correlation between the Extent of Fire and Smoke Damage and the Response Time

All fixed property, all residential dwellings, one- and two- family dwellings, store and office occupancies, and industrial and defence property were analyzed for a correlation between the response time and the extent of flame and smoke damage. There were about 40 percent less incidents than there were for the total dollar loss and percent loss for each category due to a large number of nonstructural incidents (having a value of 8). The results are shown in Figures 46 through 55. Only the all fixed dwelling and all residential dwellings had a definite increasing trend. All fixed property tended to increase from about 2.5 to 4.5 over the 10-minute range and the residential occupancies tended to increase from 1 to 4 for the first three minutes. The remaining categories clearly had too few incidents to draw any conclusions.

4. Correlation between the number of Casualties and the Response Time

Due to the low number of incidents with casualties (200), this measure was only analyzed for the all fixed dwellings. Figure 56 shows the mean number of casualties as a function of the response time. There appears to either be insufficient information or there is no relation between the response time.

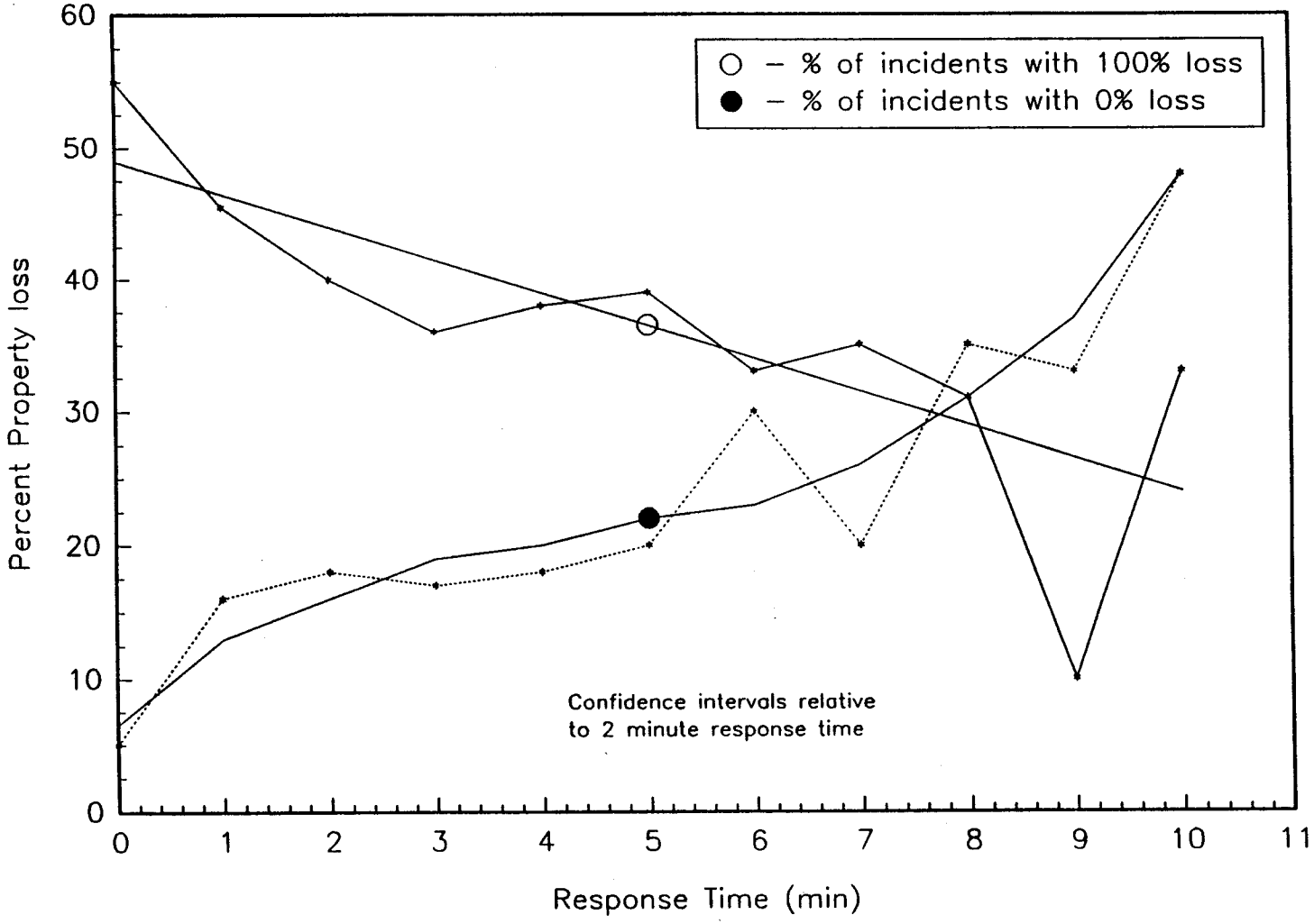


Figure 45. Variation of 0 Percent and 100 Percent Fire Loss Incidents – All Fixed Occupancies

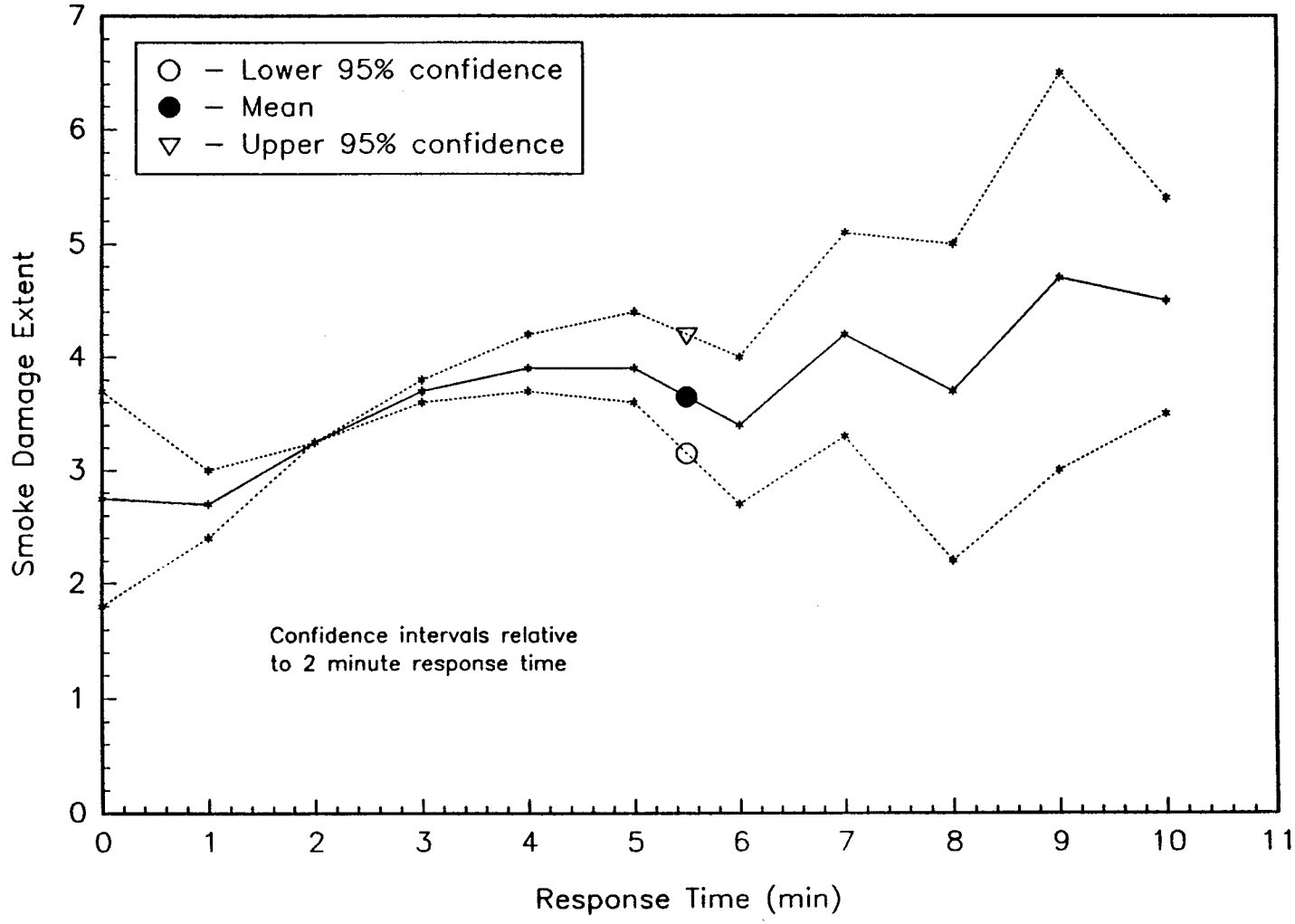


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Figure 46. Mean Extent of Smoke Damage – All Fixed Occupancies

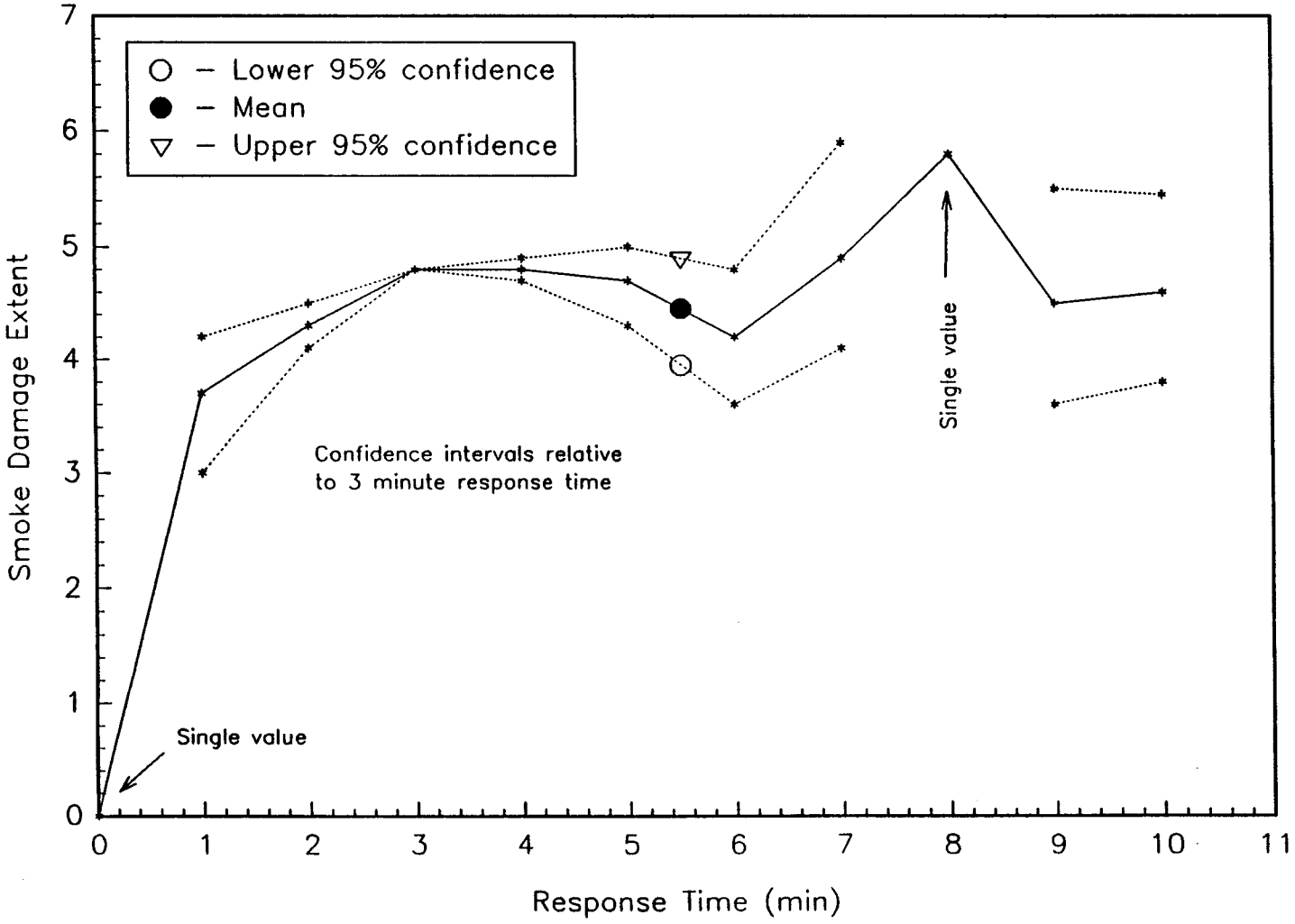


Figure 47. Mean Extent of Smoke Damage – All Residential Occupancies

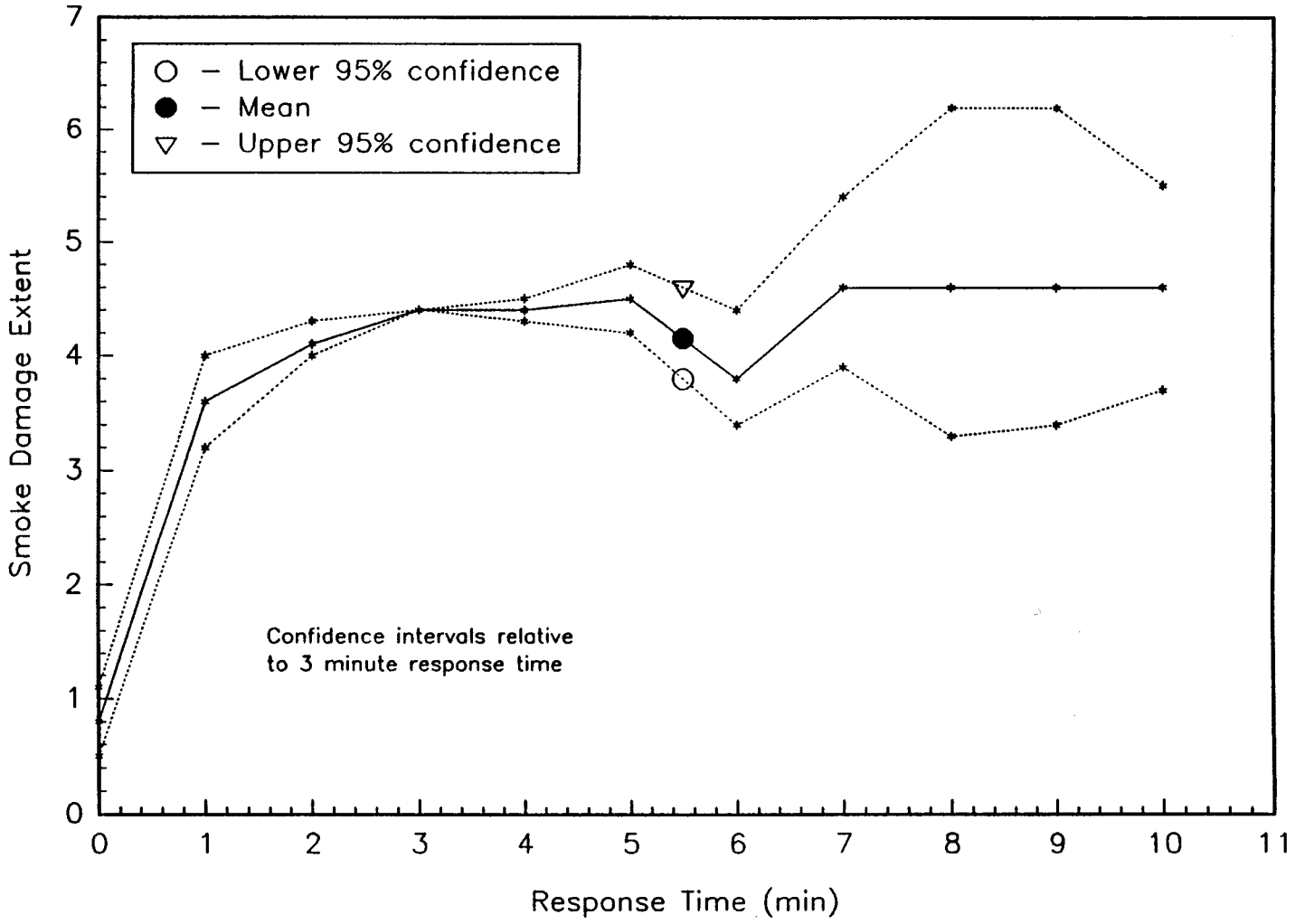


Figure 48. Mean Extent of Smoke Damage – All One- and Two-family Dwellings

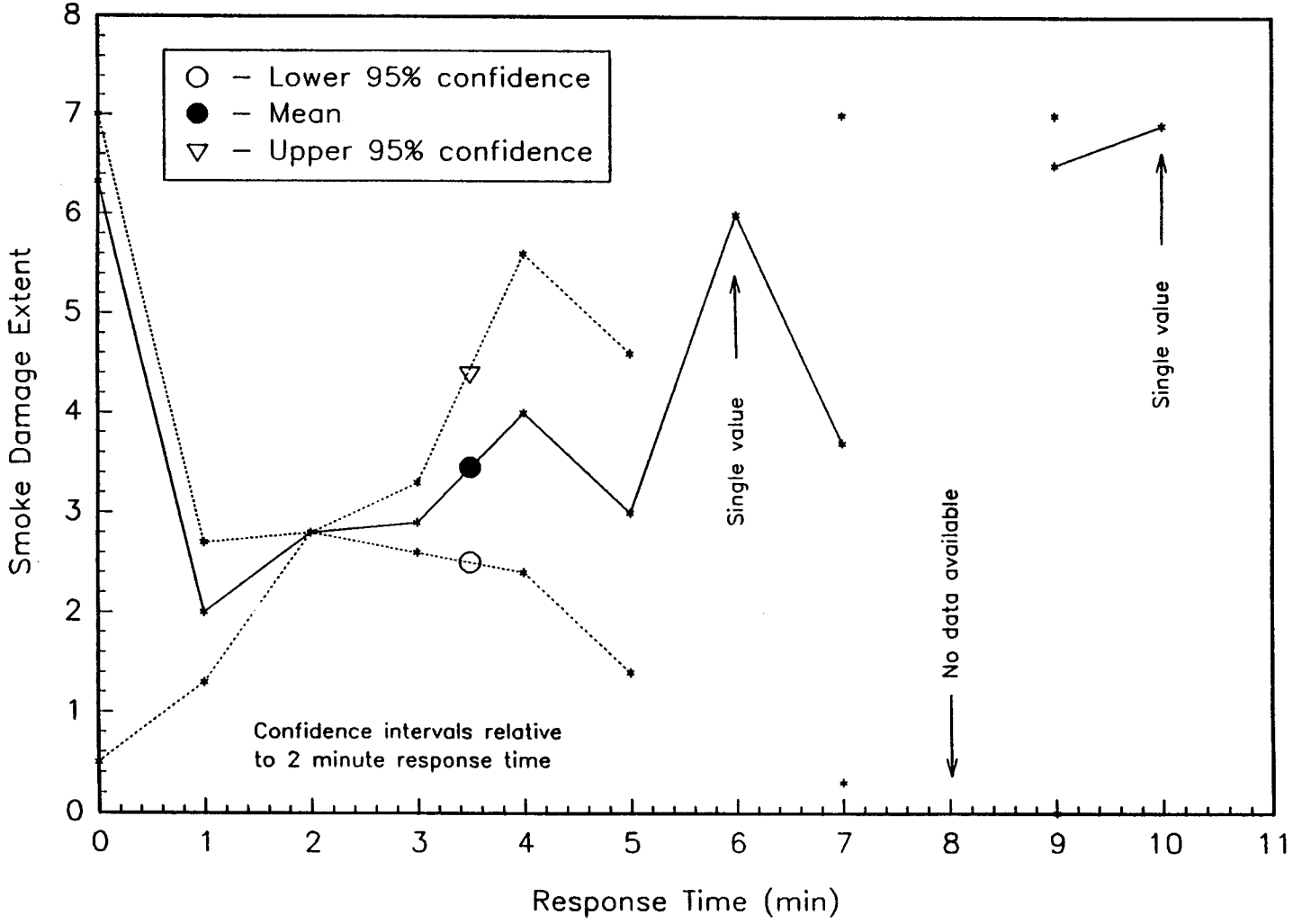


Figure 49. Mean Extent of Smoke Damage – Store and Office Occupancies

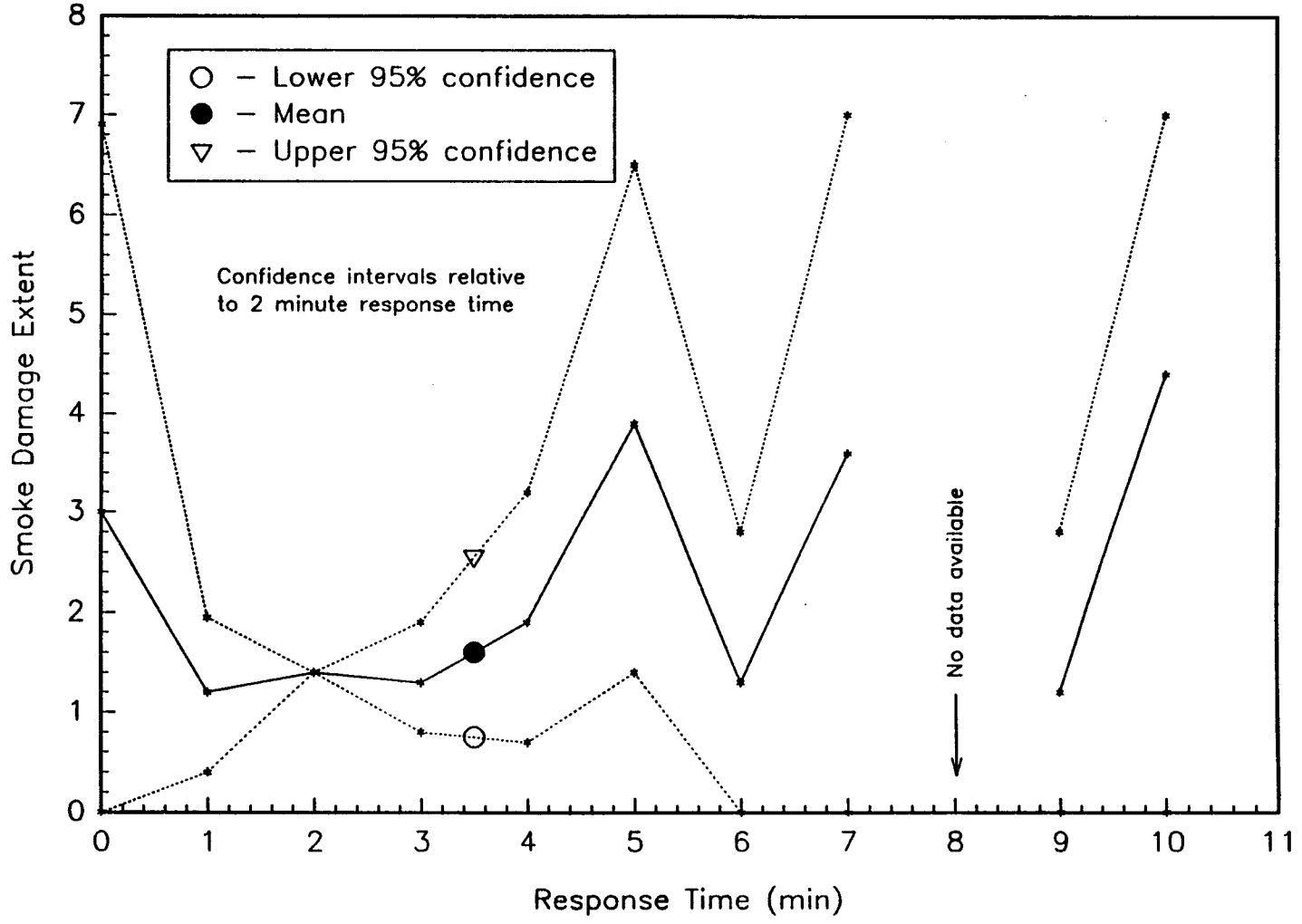


Figure 50. Mean Extent of Smoke Damage – Industrial Occupancies

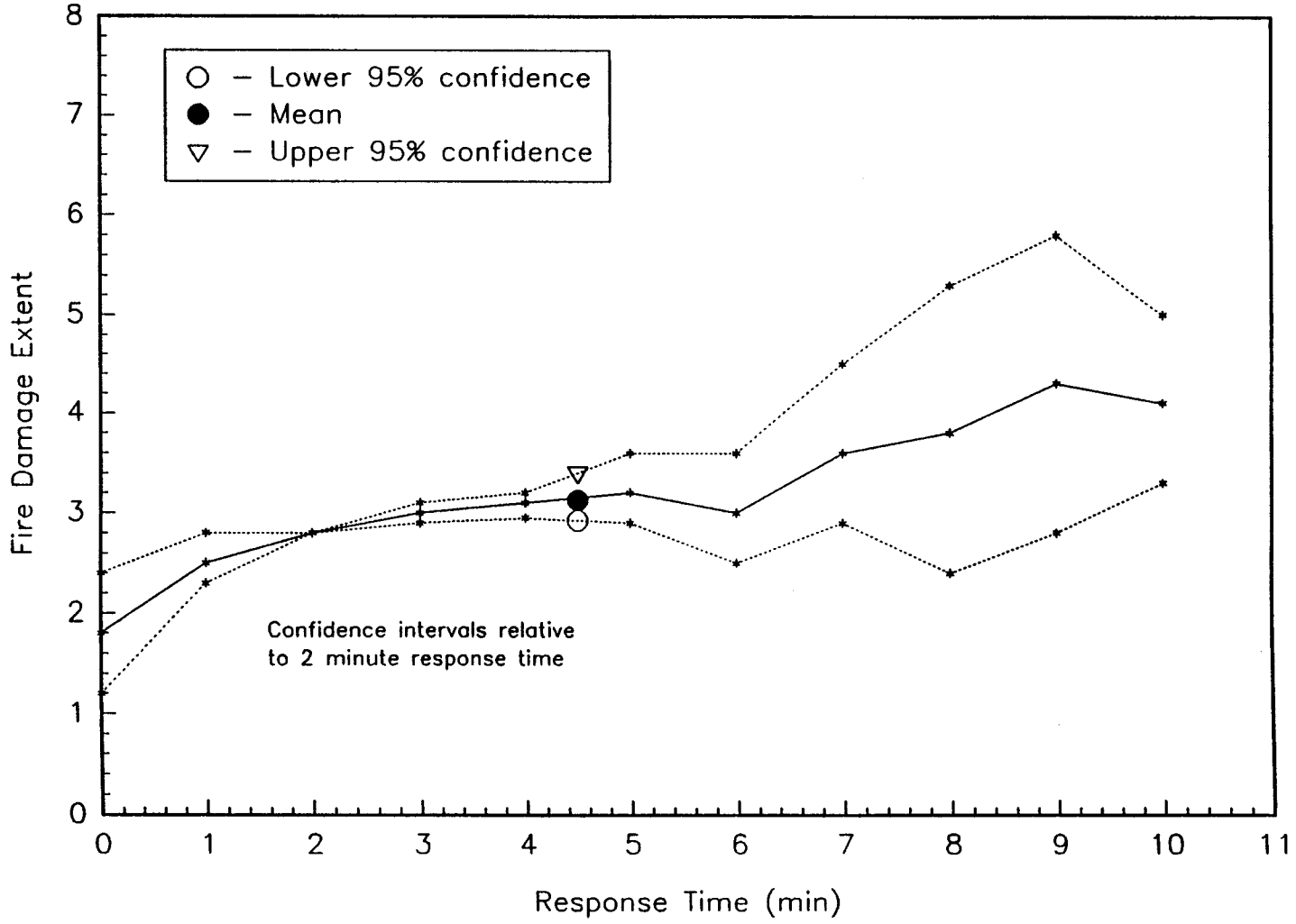


Figure 51. Mean Extent of Fire Damage – All Fixed Occupancies

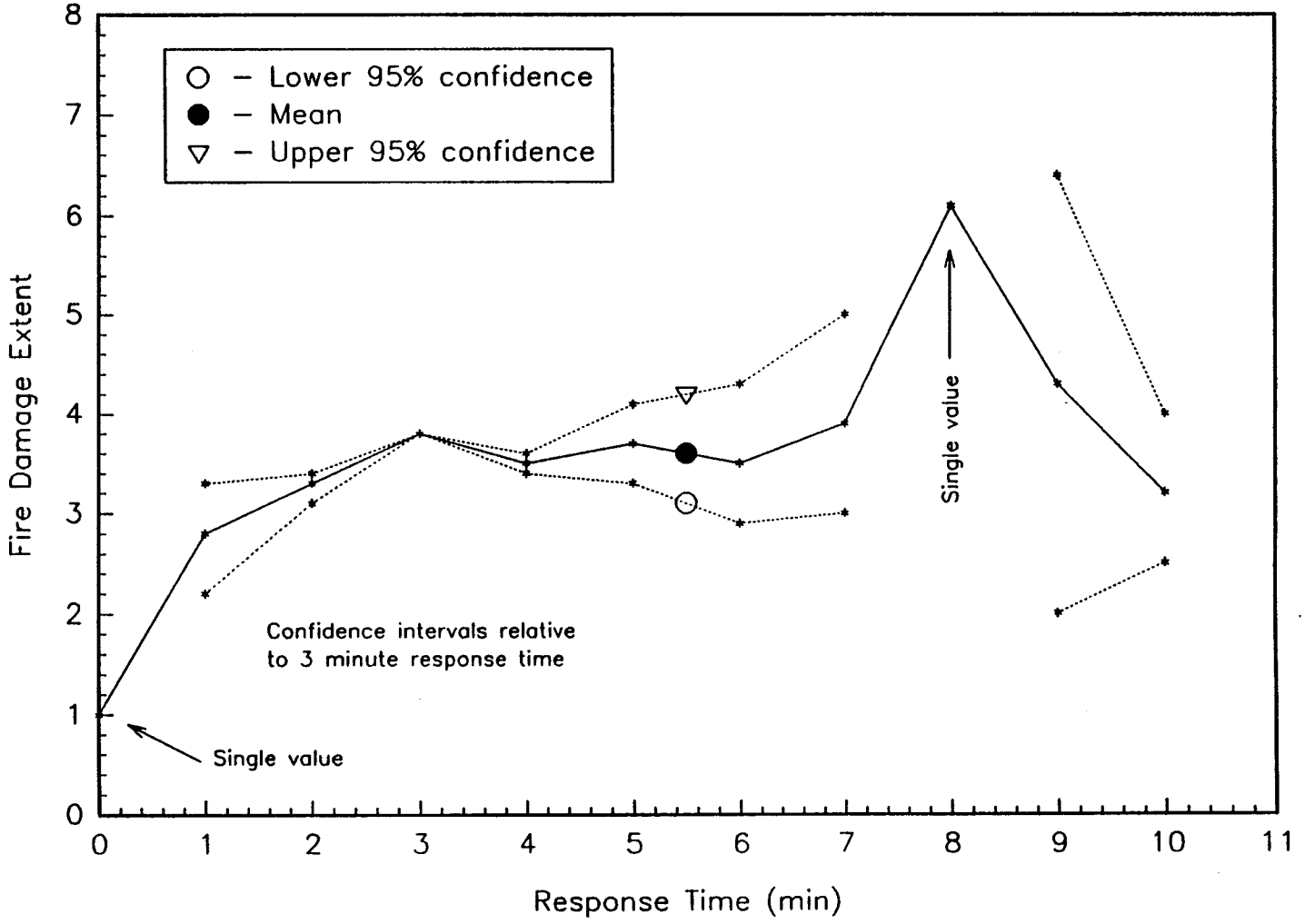


Figure 52. Mean Extent of Fire Damage – All Residential Occupancies

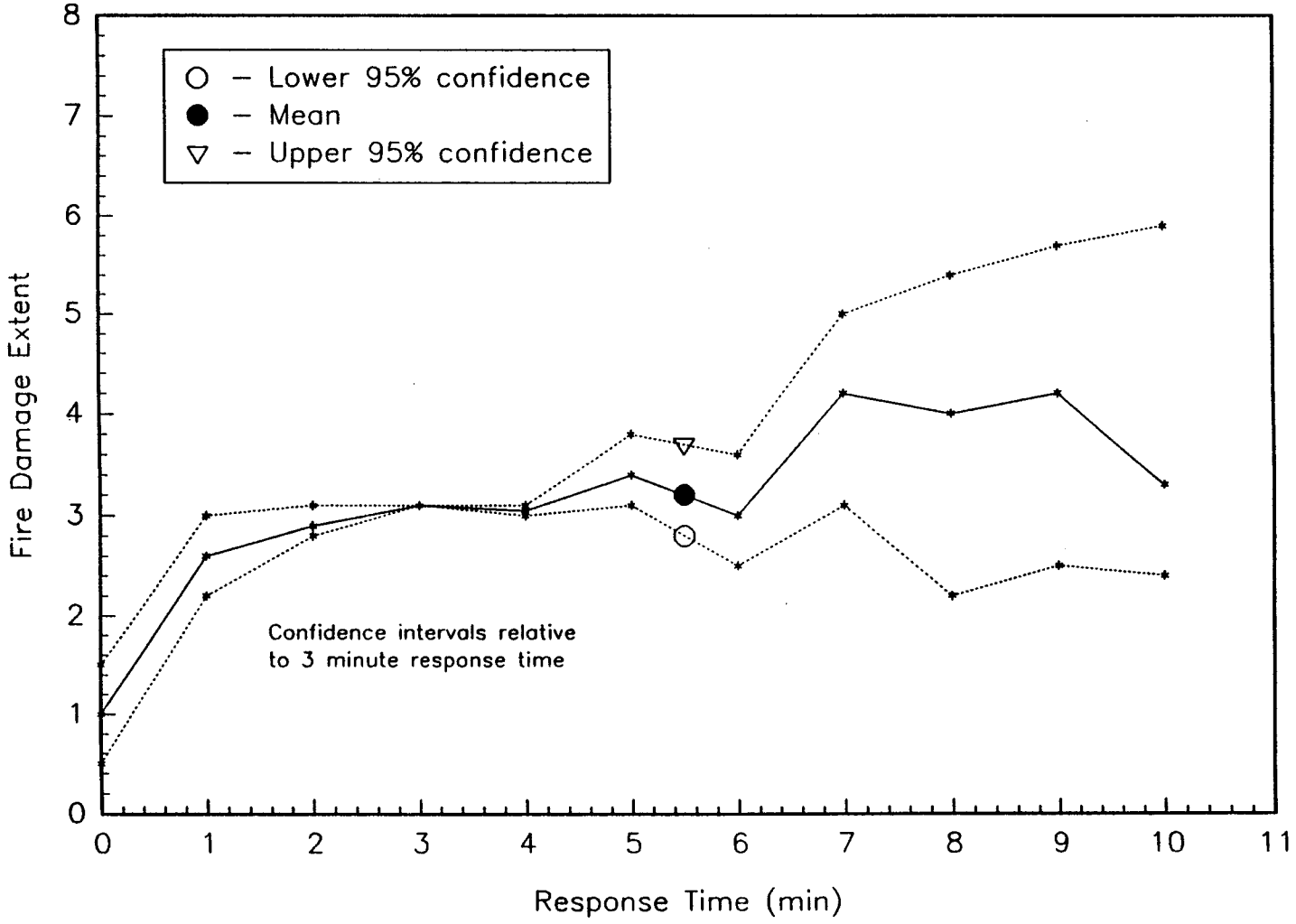


Figure 53. Mean Extent of Fire Damage – One- and Two-family Dwellings

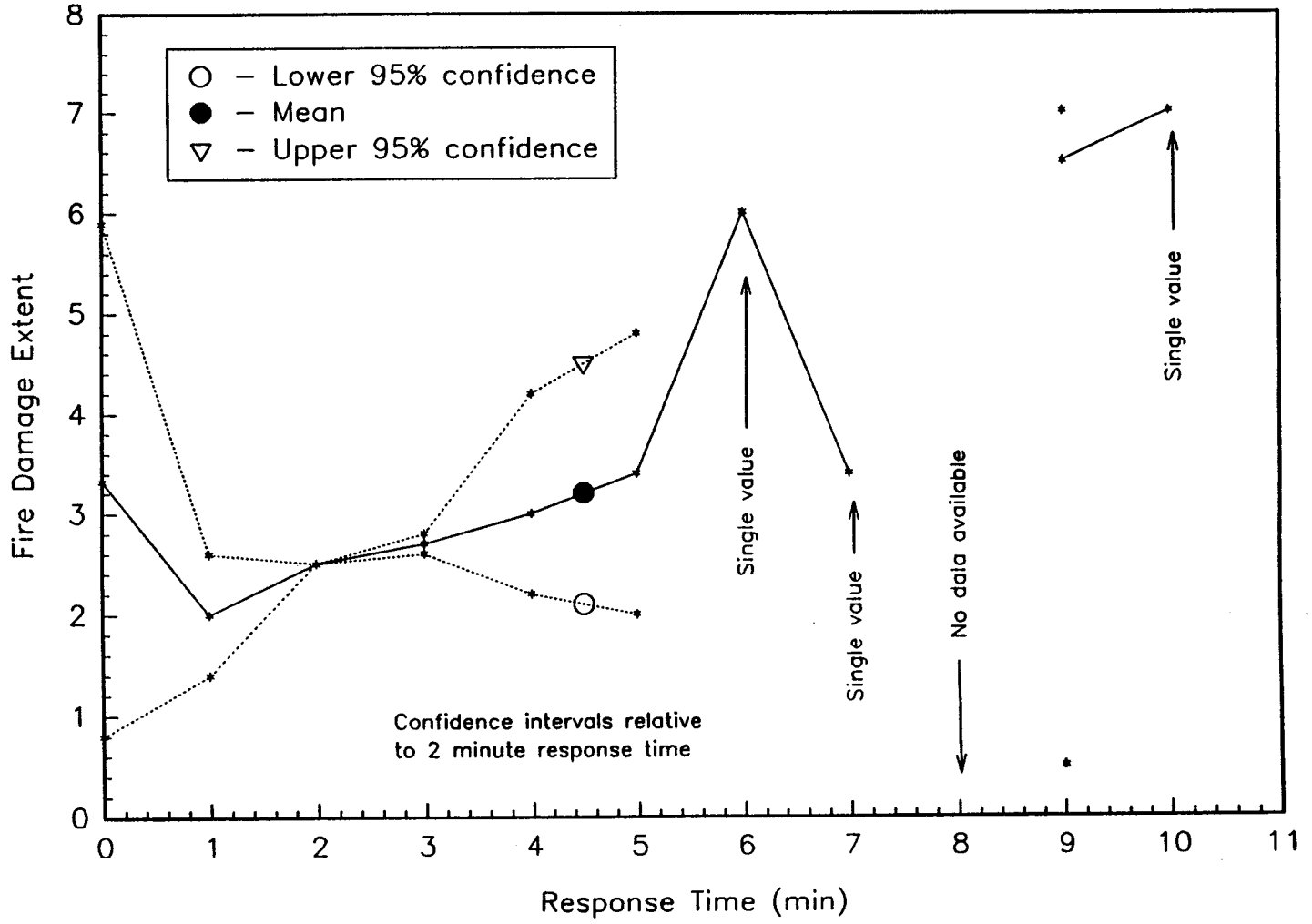


Figure 54. Mean Extent of Fire Damage – Store and Office Occupancies

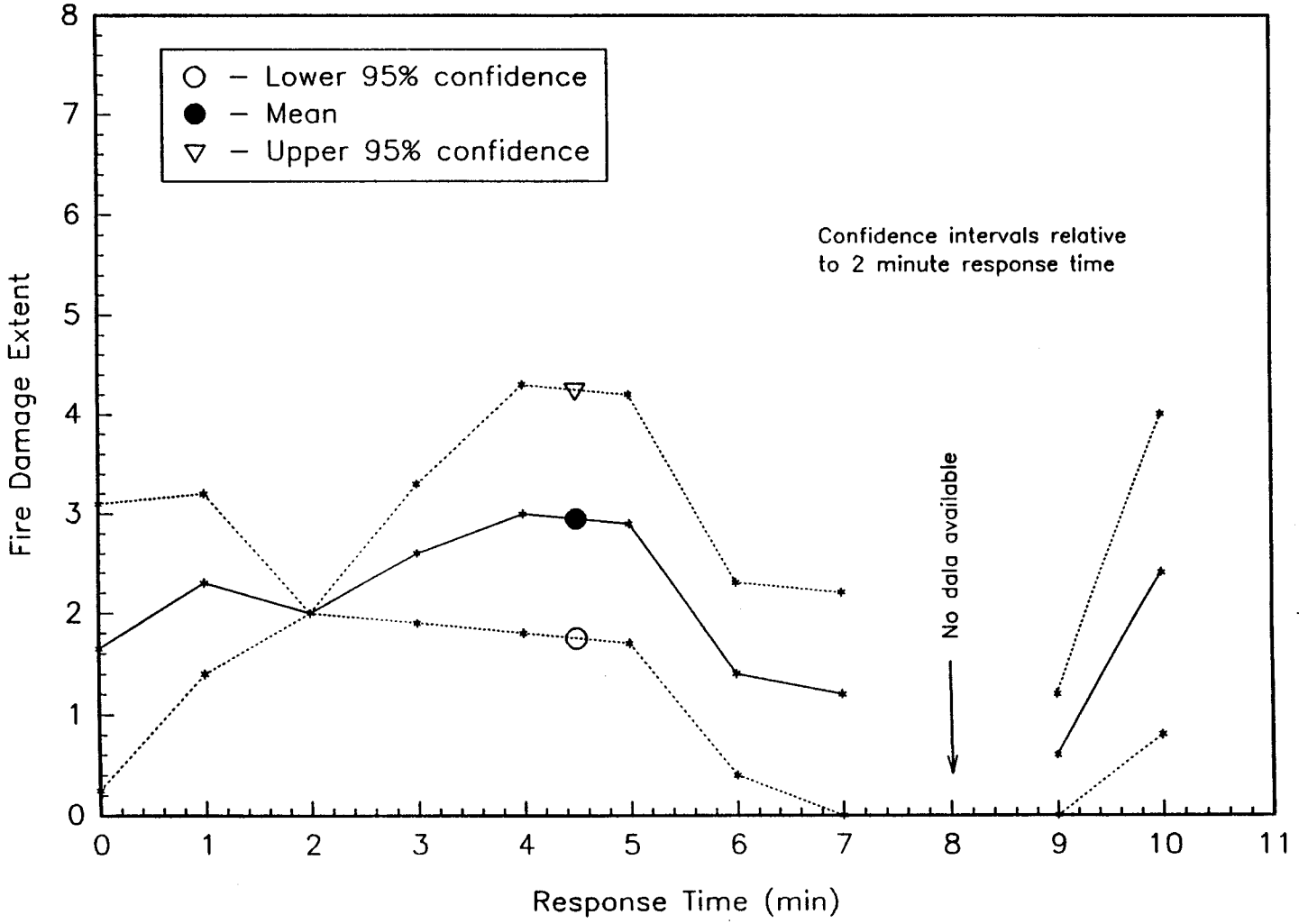


Figure 55. Mean Extent of Fire Damage – Industrial Occupancies

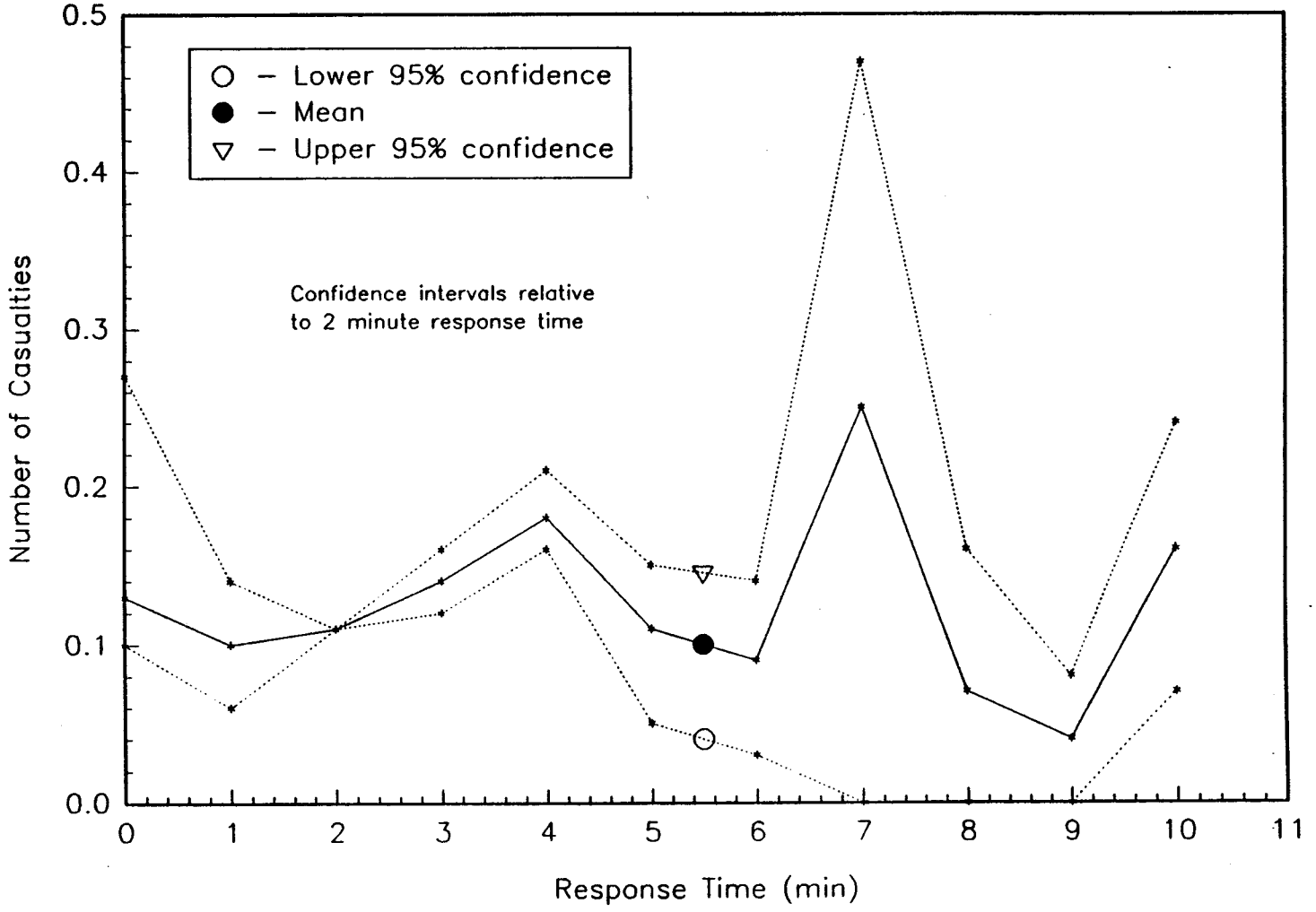


Figure 56. Casualties – All Fixed Occupancies

G. CONCLUSIONS

The conclusions are as follows:

1. As a function of response time, there was found to be an increase in the total dollars lost for all fixed property, all residential dwellings, and passenger road vehicles. The increase was approximately linear and ranged 20 to 80 percent greater than the value at the zero minute response time. This represented about a $5000 to $10,000 increase in loss between a zero minute and a five minute response time. The remaining categories were inconclusive due to the limited sample size. Data in all the categories were sparse past the five or six minute response time mark, but still showed an increase over the early response times for categories with large numbers of incidents. The store and office occupancies and the industrial and defense occupancies showed clear signs of too few incidents via a large number of single and missing points, and large confidence intervals.

2. The percent of the value lost increased in a similar manner as the dollars lost for all fixed properties, one and two family occupancies, miscellaneous property, and passenger road vehicles. The data tended to increase sharply between the 0- and 1-minute response times and increased gradually between the 1- and 4-minute response times. Typically, these categories had 20 percent more loss at 4 minutes than at 0 minutes. After 4 minutes, the confidence intervals indicate that the sample size is too small to draw conclusions. The poor results may also be a result of the bimodal distribution of the percent loss. Approximately 65 percent of all the percent loss values are either zero percent or 100 percent. There is a gradual shift from zero percent losses to 100 percent losses as the response time increases, which is partly responsible for the observed increases. However, such an unusual distribution is not easily analyzed with ordinary statistical methods.

3. The amount of flame and smoke damage increased sharply for the first four minutes of response time for all fixed dwellings. It was marginally inconclusive for one and two family dwellings. After four minutes response time, the confidence interval ranges were too large to positively identify an increase. As with the other measures, there was not enough data for these time intervals. Since the number of incidents in each category for this measure were about 40 percent less than the number in other measures (due to the elimination of nonstructural fires), more categories were inconclusive. The result of the increase in flame extent and smoke damage suggest that there is a correlation between dollar loss and percent damage for occupancy groupings that have a large number of incidents.

4. There was no detectable pattern that could be inferred between the number of casualties and the response time. There were only 200 incidents with casualties, which indicates that there were not enough incidents to draw any conclusions. Since this category showed the least dependence on response time, it is possible that the number or likelihood of casualties is independent of the fire department response time.

5. For fighters/attack aircraft, a response time relationship to any of the parameters could not be established because of the small sample size (44).

6. Analysis of a larger database (such as NFIRS) may provide a quantifiable correlation between the response time and dollar loss for such occupancies as residential and office. This analysis is included in the following chapter.

SECTION IV
THE EFFECT OF CIVILIAN RESPONSE TIME ON FIRE LOSSES

A. PURPOSE

This analysis provides an assessment of the effects of the fire department response time to a fire incident on the expected property loss based on the National Fire Incident Reporting System (NFIRS) for the year 1989. The objective is to develop a correlation between the response time and dollar loss so that the impact of changing fire department locations can be quantified.

The effect of manning on fire losses was also investigated during this process. However, NFIRS does not tabulate the number of first alarm responders for each fire incident. Instead, it tabulates the total number of responders for the incident so that an accurate correlation between manning and fire losses cannot be determined.

B. INTRODUCTION

To assess the impact on fire losses that result from fire department changes that alter the response time to fire incidents, an analysis was conducted that correlated the fire department response time to the average property dollar loss. This was initially done on the Air Force fire incident database (see Chapter 3) and was then done on the much larger National Fire Incident Reporting System (NFIRS) for 1989.

C. PROPERTY TYPES AND CATEGORIES

The data was analyzed by categories. Categories were based on the fixed property use (see Section III, B) and mobile property use (automobile, aircraft). NFIRS was only analyzed based on the fixed property use. Miscellaneous property includes open lands, roads, railroads, waterways, aircraft areas, and other unusual occupancies. It was assumed that homogeneous categories would yield the most reliable results. However, refining categories reduces the pool of incidents and decreases the statistical reliability. NFIRS was used because the Air Force database was too small for most homogeneous categories (except for residential and 1 and 2 family occupancies). The NFIRS database does not include any military aircraft mishaps nor incidents that occurred on an Air Force base. There are also a very limited number of incidents that occurred at airports. Thus, the major function of the NFIRS database analysis is to determine the response time/dollar loss correlation for fixed property occupancies which are expected to be similar to those located on Air Force bases.

D. DAMAGE QUANTIFICATION

Damage assessment was based on the categories listed in Section II, C, 5. The extent of flame and smoke damage was used as comparisons between NFIRS89 and the Air Force databases. The number of casualties was also listed for each category. Casualties were only analyzed for the category of residential in this study. There was no

way to determine the percent damage to the structure as was possible with the Air Force database since the total property value was not reported or estimated.

E. SELECTION OF RECORDS

Unsuitable incidents which were not included in the analysis included missing dollar losses, unrealistic response time reports, and fires not controlled by the fire department. Table 8 summarizes the approximate percentage of data that fell into such categories. Since the percentage is for the entire database, some incidents have two or more unsuitable characteristics. Table 9 indicates that only about 20 percent of the incidents in a group are actually useable. Thus, they are only approximate.

TABLE 8. EXCLUSION OF INCIDENTS

Reason for Exclusion	Percent of DB
Repeated incident due to multiple casualties	2.5
Missing dollar loss	14.7
Service calls	about 0
Nonfire situations	about 0
Missing or unreal time values	15.5
Unrealistic alarm time/response time sequence	0.02
Unreasonable response time (3 hrs or longer)	21.6
Eliminates zero dollar losses	45.0
Fire not extinguished by fire department	40.0

This reduces the workable size of the NFIRS database to about 137000 incidents (18 percent). By comparison, about 40 percent of the Air Force database incidents (3200) were retained.

F. DESCRIPTION OF NFIRS CONTENTS

NFIRS database contains inherent biases and nonnormal distributions for a number of parameters of interest. Biases arise as a result of individual assessment of dollar loss and extent of damage. Non-normal distributions arise as a result of boundaries placed on the outcome of an incident such a positive dollar losses and response times. The next sections illustrate the distributions of various parameters.

1. Number and Distribution of Incidents by Category

The NFIRS fire incident database included approximately 760000 records. Due to the large size of NFIRS (each record is 614 bytes), it was not practical to determine the exact number of incidents. The incidents are categorized in a manner almost identical to the Air Force database. The number of incidents in selected categories are listed in Table 9.

TABLE 9. NUMBER OF INCIDENTS IN CATEGORIES

Category	Incidents	Category	Incidents
All Residential	239000*	Energy Production	225
1&2 Family	175000*	Laboratories	244
1&2 Family All Year	170000*	Communication	205
Apartments	56631	Utilities/Energy	2488
Boarding	700*	Manufacturing	11377
All Hotels	2300*	Plastics/Chemical	1131
Dormitories	620*	Metals Manufacture	2981
Small Hotels	210*	Storage	26109
Health Care	5190	Petroleum Manuf.	258
Prison	741	Plastic Storage	256
Educational	6708	Vehicle Storage	10987
Restaurants	6985	Aircraft Hangars	34
Mercantile/Business	25089	Miscellaneous	407017
Offices	4928	Landfills	910
Industry/Defence	17993	Railroad	2442
*Estimate		Aircraft Areas	285

Several of the categories are subsets of other categories, such that the sum of all listed incidents exceeds the total number of incidents in the database. 85.4 percent of the incidents are classified as either residential or miscellaneous (railroad, open land).

2. Number and Distribution of Incidents by Response Time

The distribution of response times was found to be non-normal. The majority of response times were concentrated at 2-3 minutes and tapered off to as high as 1.5 hours. Figures 57 and 58 show the frequency distribution of the response times for all residential property for 0 to 30 and 30 to 120 minute intervals respectively. Note that for the later response times, the number of incidents that fall on a multiple of five is several times greater than the number that fall in the immediate vicinity. The distributions for other occupancies are similar.

3. Number and Distribution of Incidents by Total Dollar Loss

The frequency of the dollar loss per incident was also not normally distributed. Although most incidents had only 2 or 3 significant digits in the dollar loss, many had more. In order to achieve a more uniform distribution, the dollar loss range listed in NFPA 101 was used (Reference 3). This range restricts the number of significant figures in the loss value to 2 or less. Figure 59 shows the frequency of each dollar loss range for all residential properties in the NFIRS 1989 database. There is a marked drop off over the first few ranges and periodic peaks afterward, occurring at values such as $500 and $10000. Figure 59 only shows up to $10000 due to the large scales involved. All values have been converted to June 1993 dollars using the inflation curve shown in Figure 60.

G. METHOD OF ANALYSIS

The NFIRS data was analyzed for a correlation between dollar loss and response time using a logarithmic transformation. As shown seen in Figure 59, the frequency of the dollar loss per response time was not normally distributed. Figure 61 shows that a logarithmic transformation of each dollar loss provides a more normalized distribution. As a result of the logarithmic function, the zero dollar losses could not be transformed. Instead the probability of a zero dollar loss was determined for each response time. The transformed data may be analyzed with standard statistical methods and the results of the analysis can be transformed back to 1993 dollars.

The correlation between dollar loss and response time seeks to determine an average value at a particular response time. It was logically anticipated that as the response time increased the total dollar loss also would increase. The dollar loss correlation was also expected to be a function of the property occupancy. Homogenous property types were expected to give the best results. However, the more refined a category became, the fewer incidents that were available for analysis. As in Section III, a 95 percent confidence intervals were placed on each point (see Appendix B).

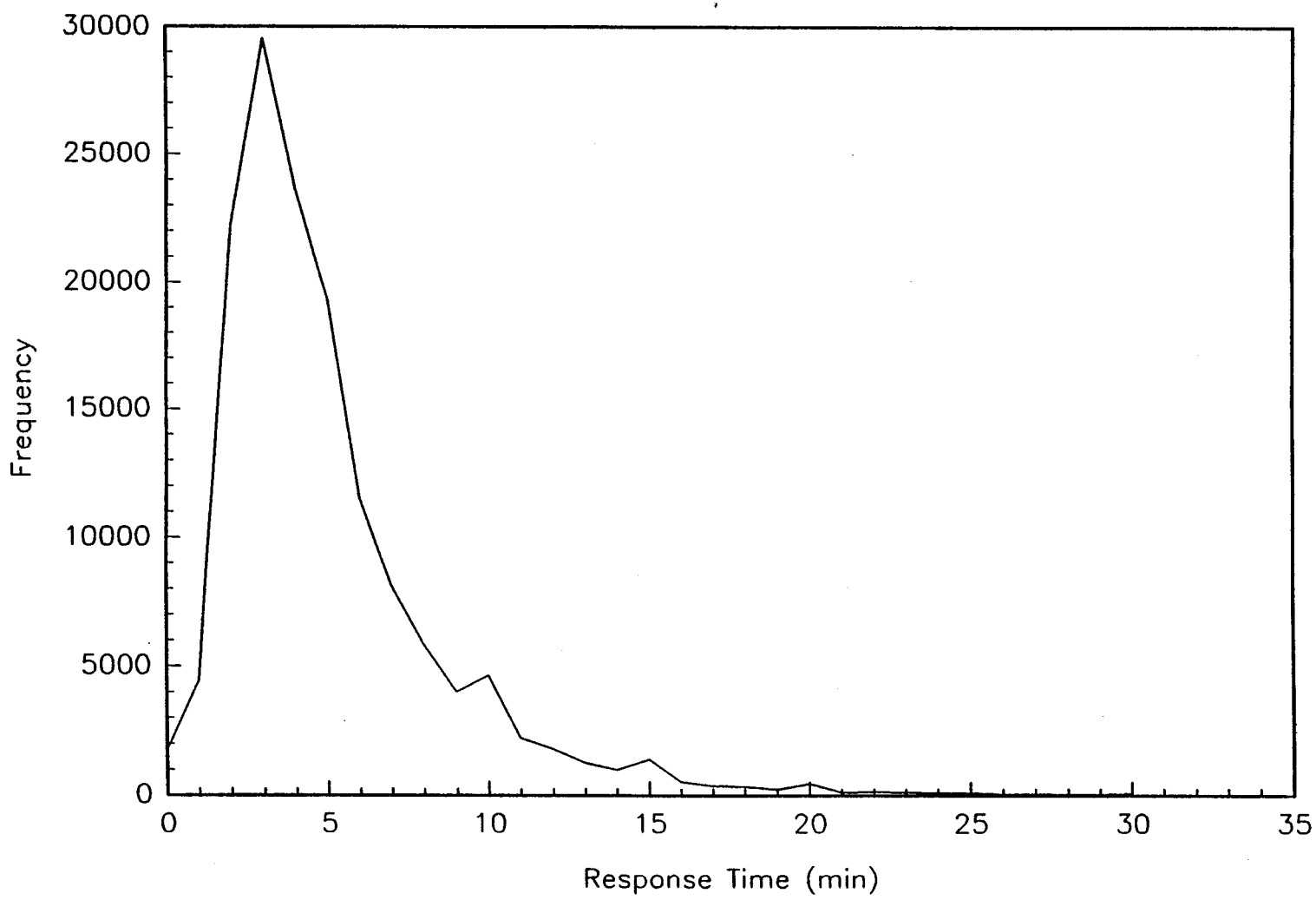


Figure 57. Distribution of Response Times for All Residential Occupancies

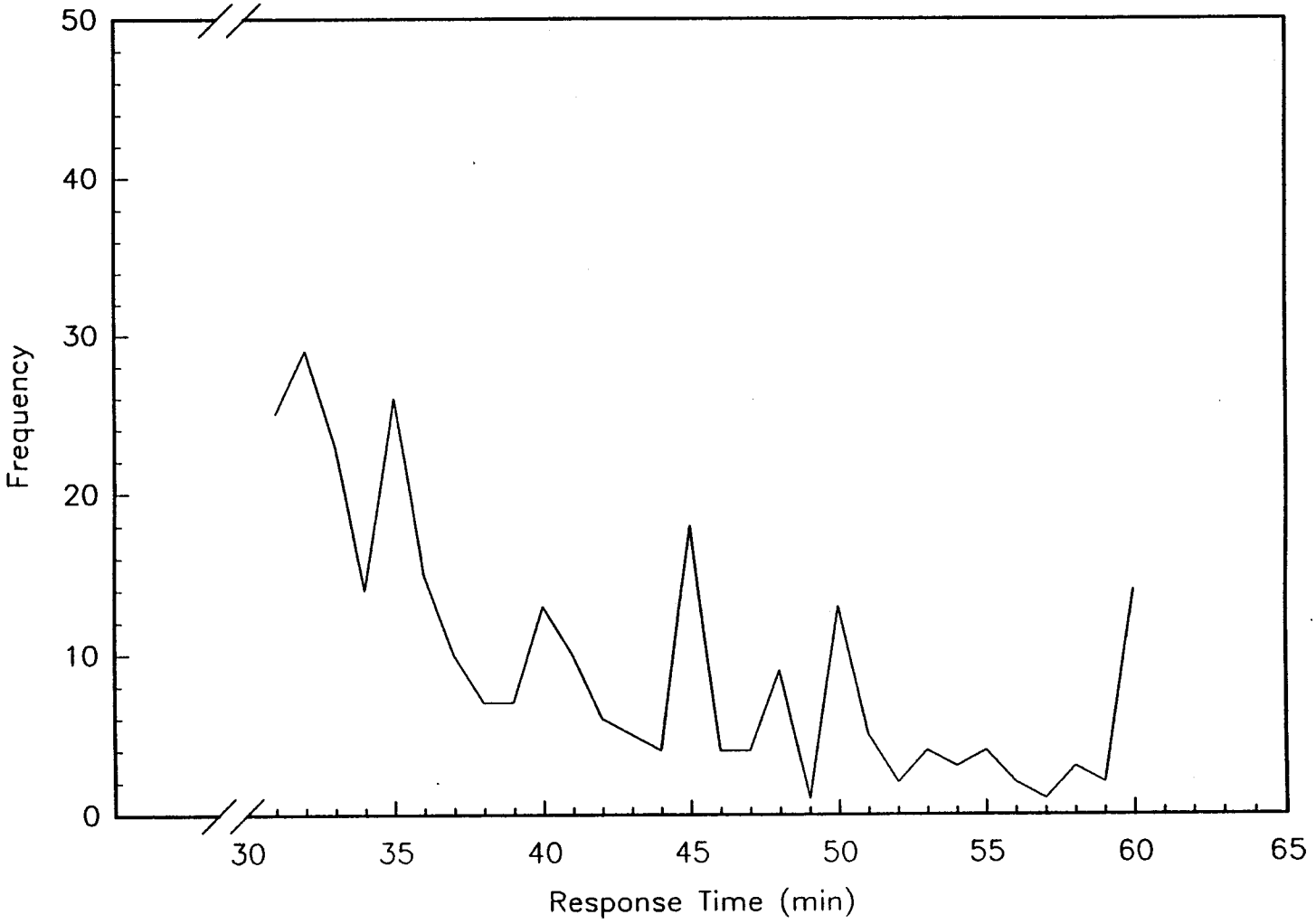


Figure 58. Distribution of Response Times for All Residential Occupancies

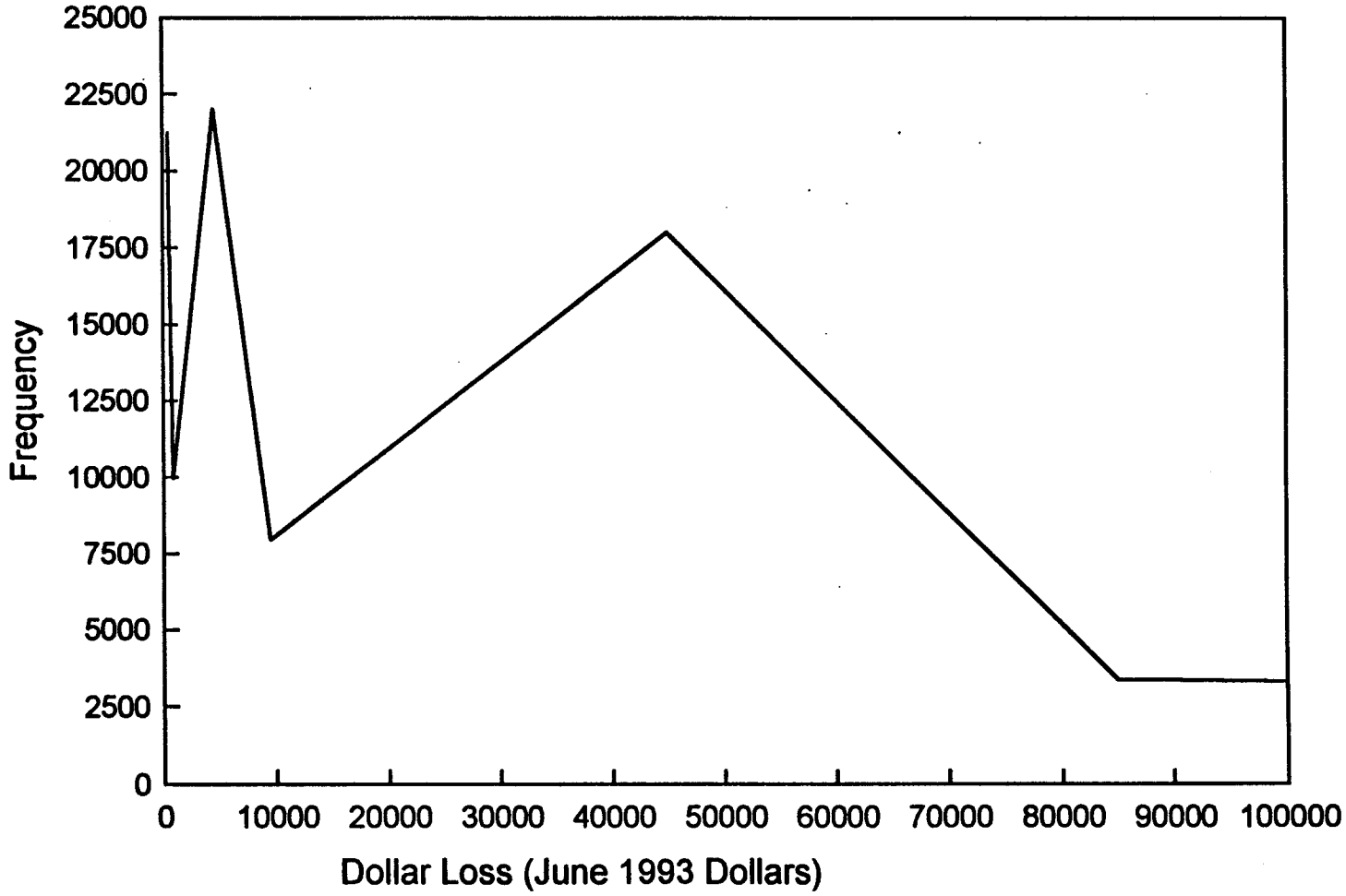


Figure 59. Distribution of Estimated Dollar Loss for All Residential Occupancies

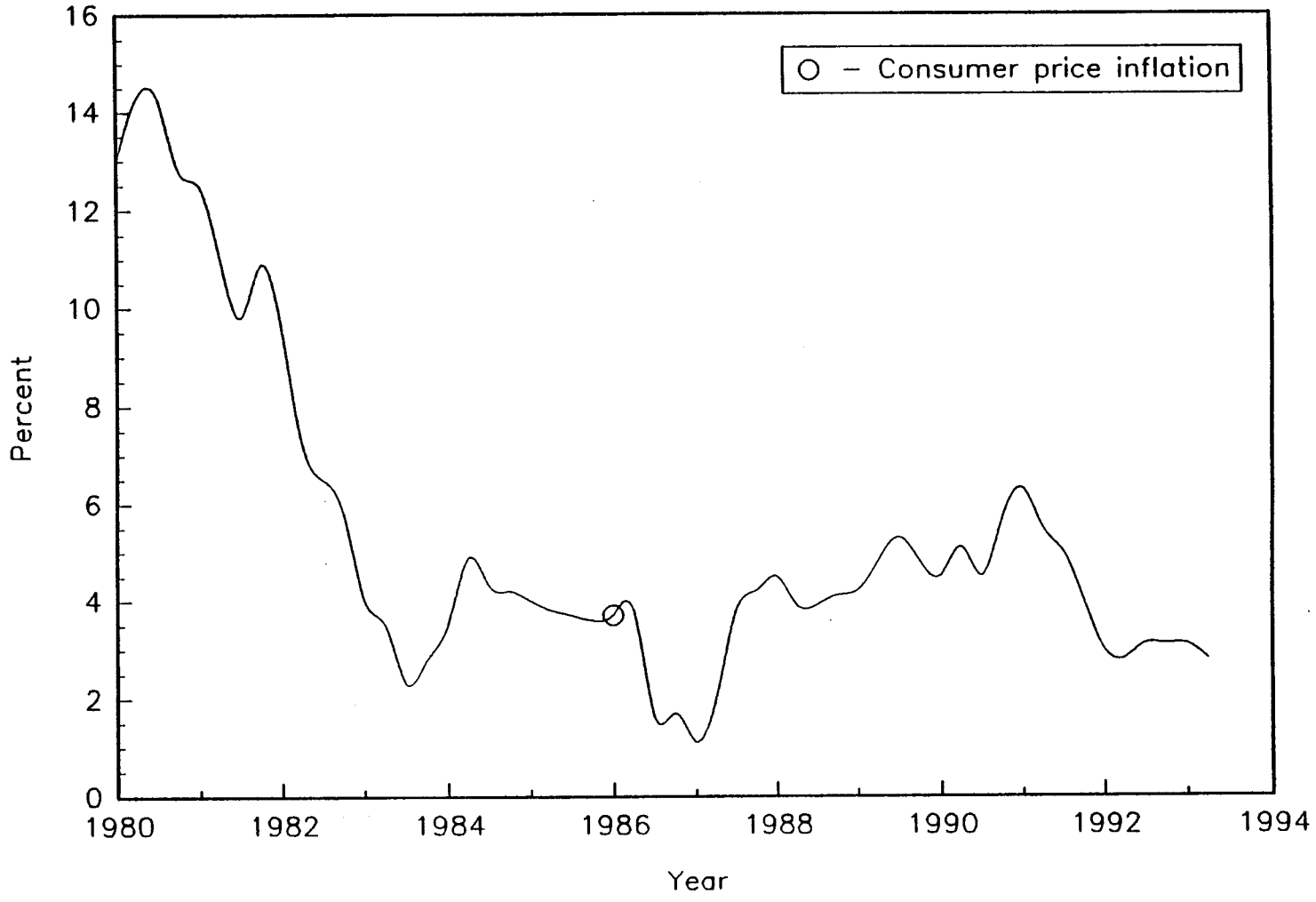


Figure 60. Inflation Values for 1980 through February 1993

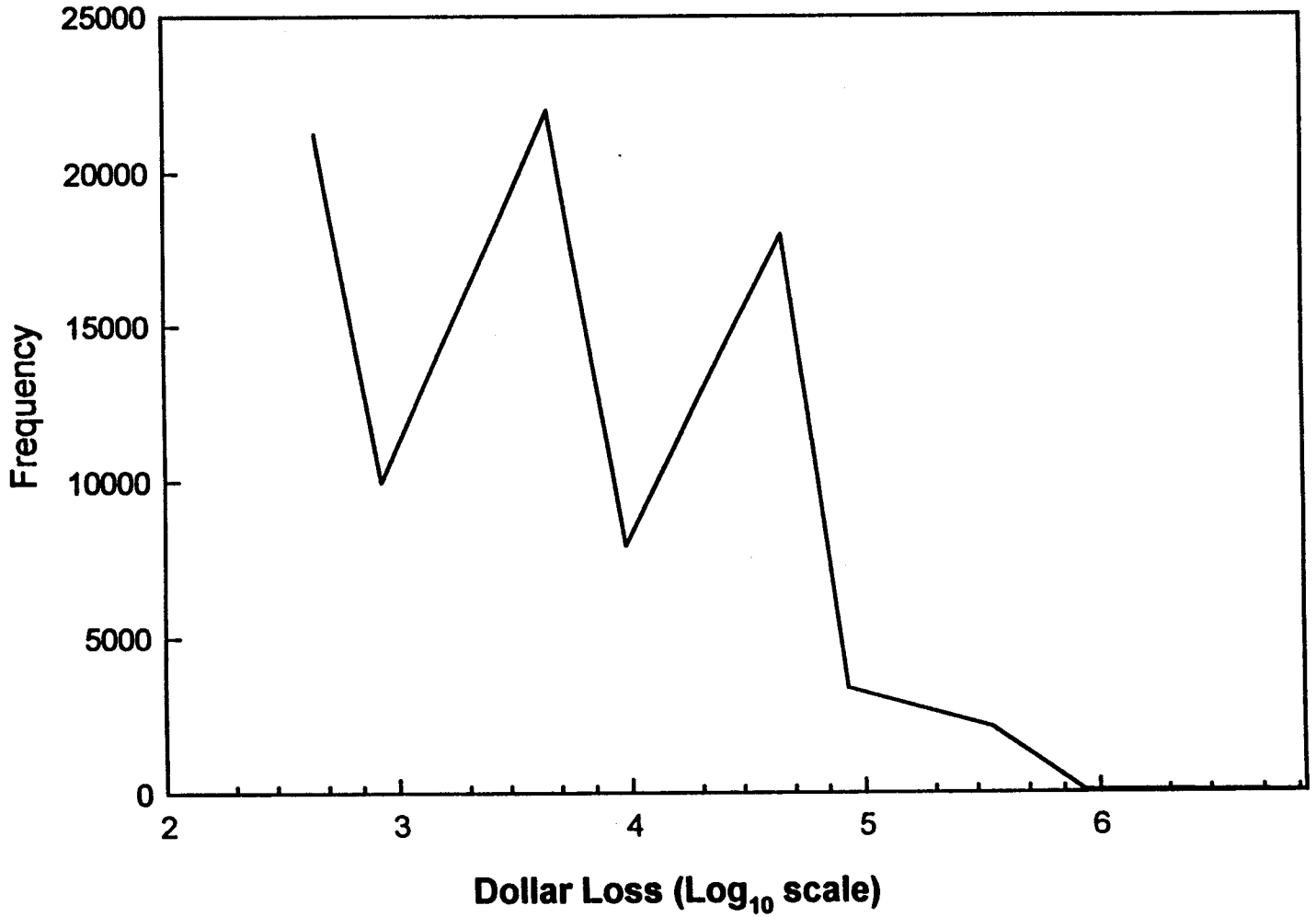


Figure 61. Distribution of Estimated Fire Loss for All Residential Occupancies

The net dollar loss per incident is computed using the probability of a zero dollar loss

$$DL = (1 - PO) \cdot MDL \tag{2}$$

where DL is the dollar loss per incident, P0 is the probability of a zero dollar loss, and MDL is the mean dollar loss, excluding the zero dollar losses, for a given response time.

The casualties were analyzed by comparing the number of casualties to the response time for all residential property. Since there was a much smaller percentage of casualties per incident, only all residential property was analyzed. Transformations and error bars were not used for this part of the analysis.

H. RESULTS

1. Dollar Loss versus Response Time

The probability of a zero dollar loss for all incidents that were retained is shown in Figure 62. A linear curve fit (also shown in Figure 62) results in the following equation:

$$P0 = 0.456 - 0.00264 \cdot RT \tag{3}$$

where P0 is the probability of a zero dollar loss and RT is the response time.

The dollar loss versus time for all categories listed in Table 9 except energy production, laboratories, communication, plastic storage, aircraft hangars, and aircraft areas are shown in Figures 63 through 86. The excluded property types had insufficient data for analysis. Eighteen types were considered suitable for a linear curve fit over all or a portion of the graph. The curve fits are shown on the applicable graphs. The coefficients for a linear equation (MDL = A + B*RT, where MDL is the mean dollar loss excluding zero dollar loss incidents) and the valid ranges are listed in Table 10. Miscellaneous property is a classification that places all fixed properties that do not fall elsewhere. Examples include streets, bridges, mines and outdoor properties. Graphs that do not have a curve fit were considered to have too little data and too large of a confidence interval for use. They are shown for illustrative purposes, however.

The larger the 'B' value, the greater the dependence on the response time. Table 10 indicates that 'B' ranges from 15 dollars/minute (utilities/energy production) to 462 dollars/minute (year round, 1 and 2 family).

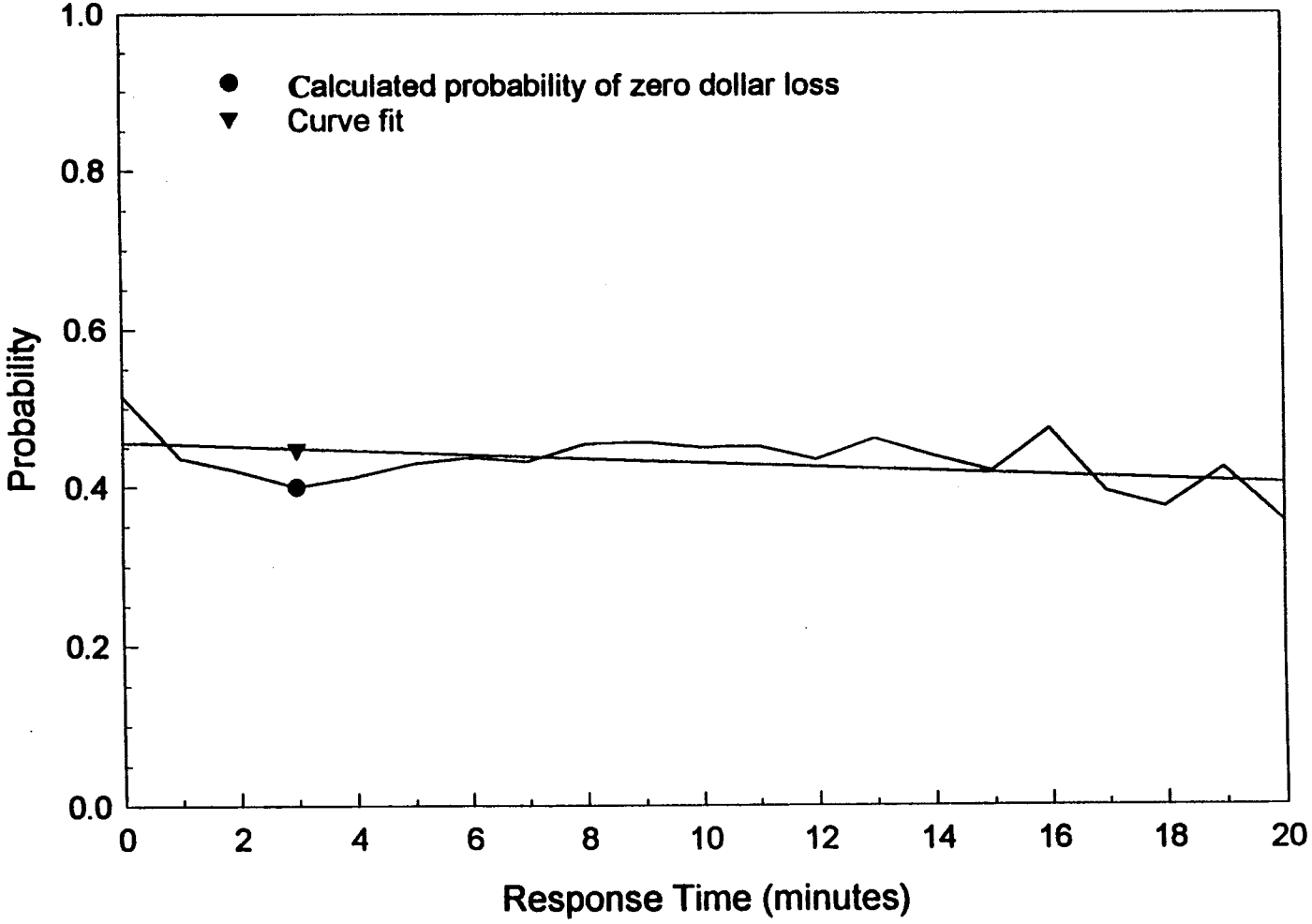


Figure 62. Probability of a Zero Dollar Loss

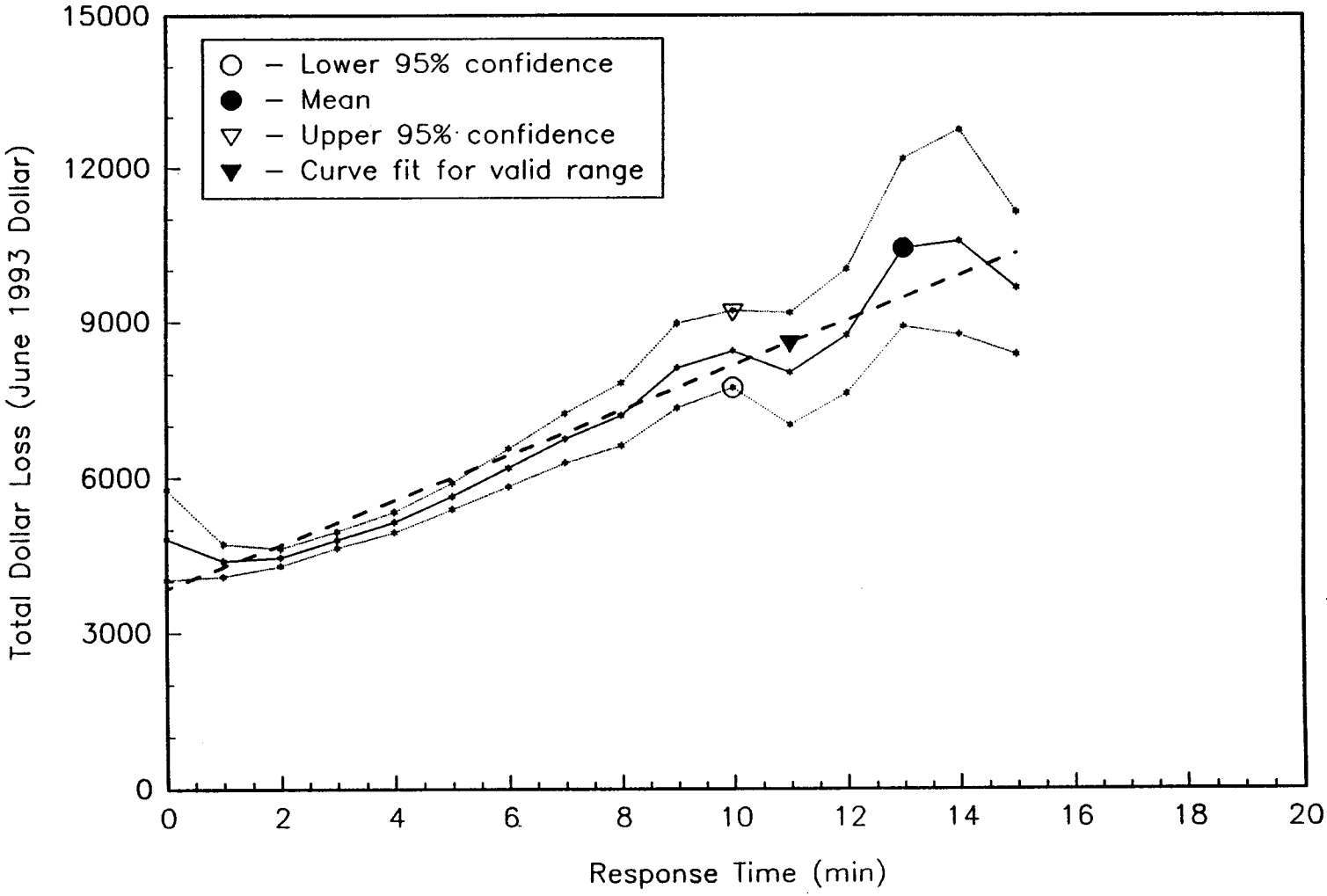


Figure 63. Effect of Response Time on Dollar Loss for All Residential Occupancies

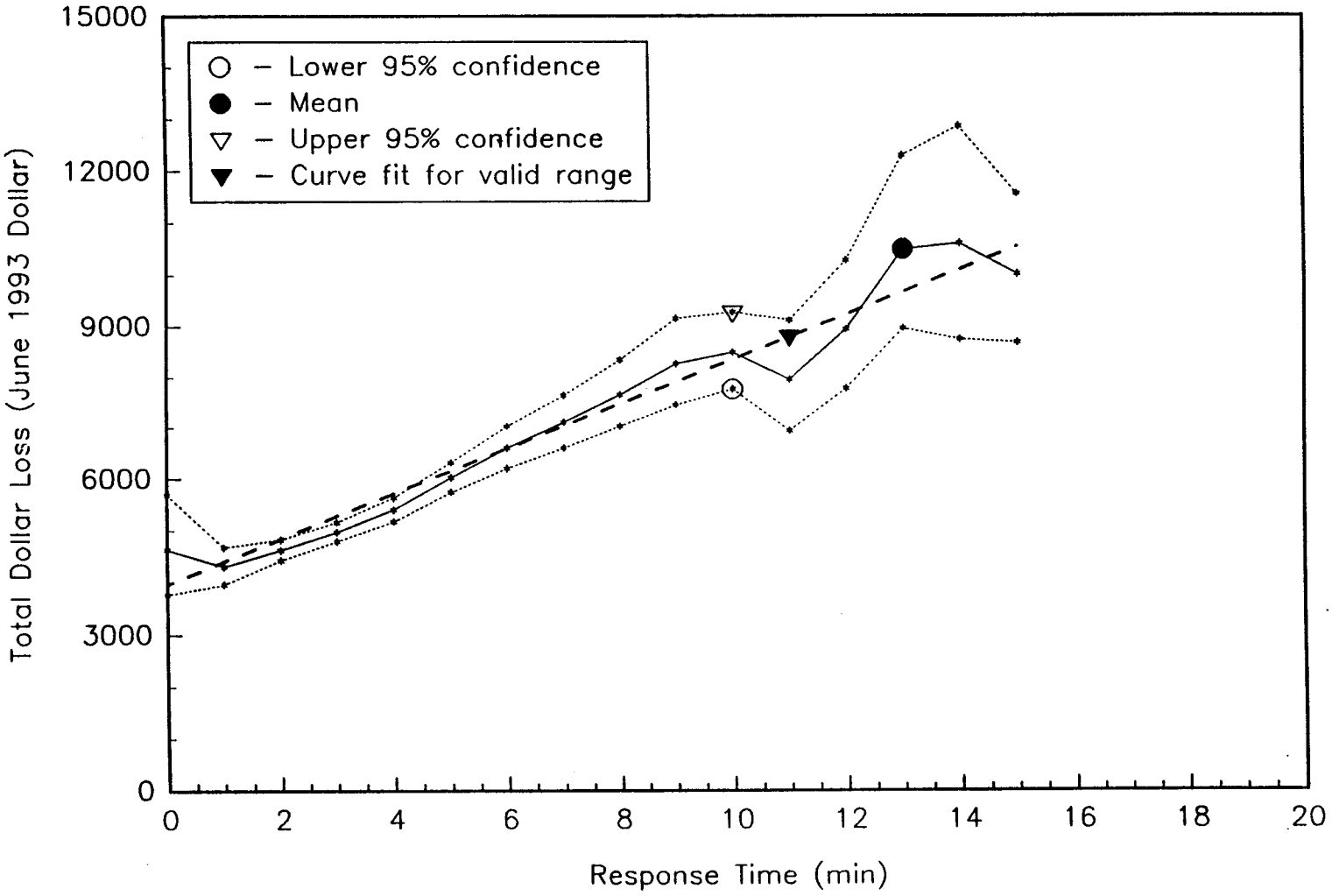


Figure 64. Effect of Response Time on Dollar Loss for All One- and Two-family Dwellings

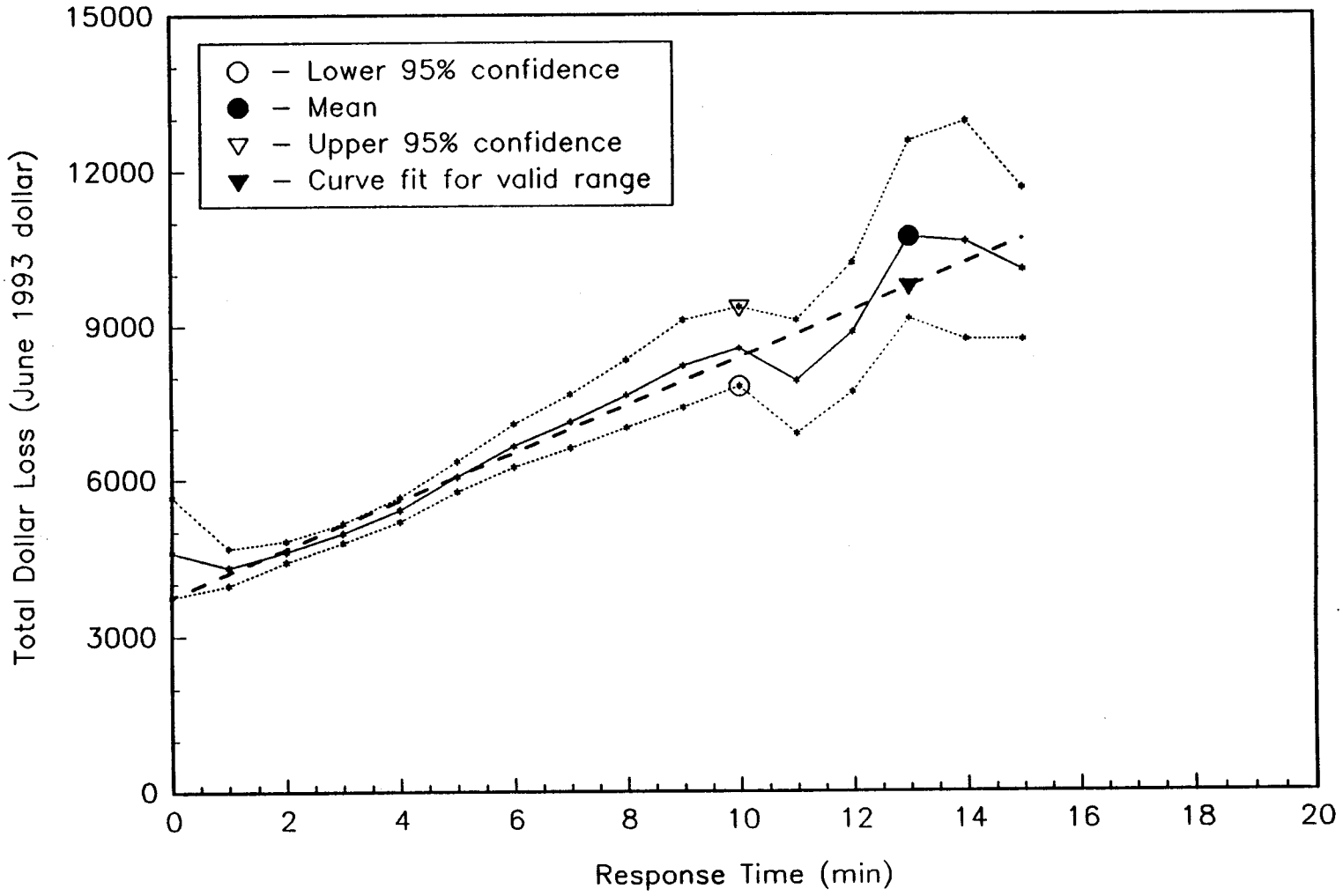


Figure 65. Effect of Response Time on Dollar Loss for One- and Two-family Dwellings Year Round

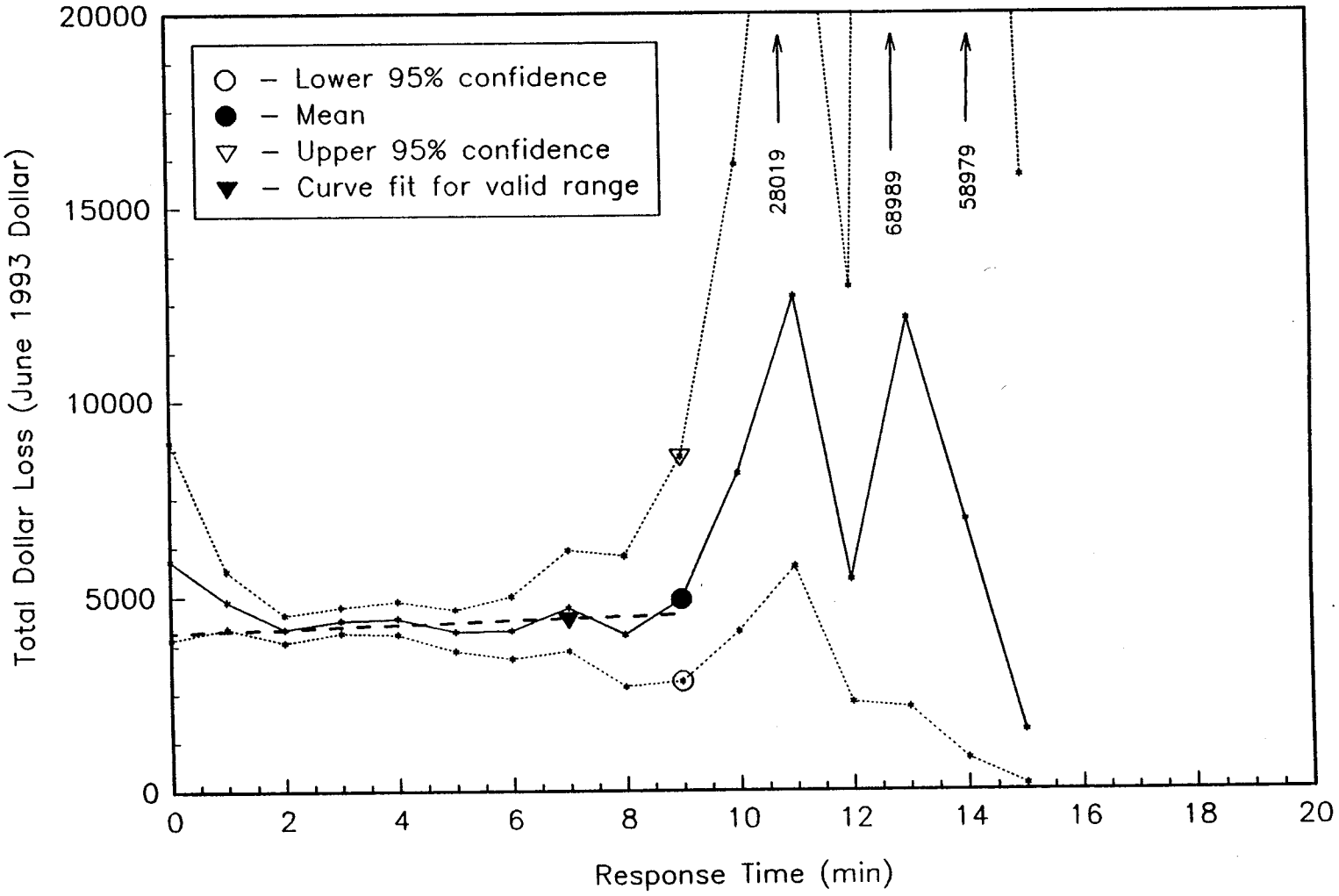


Figure 66. Effect of Response Time on Dollar Loss for Apartment Occupancies

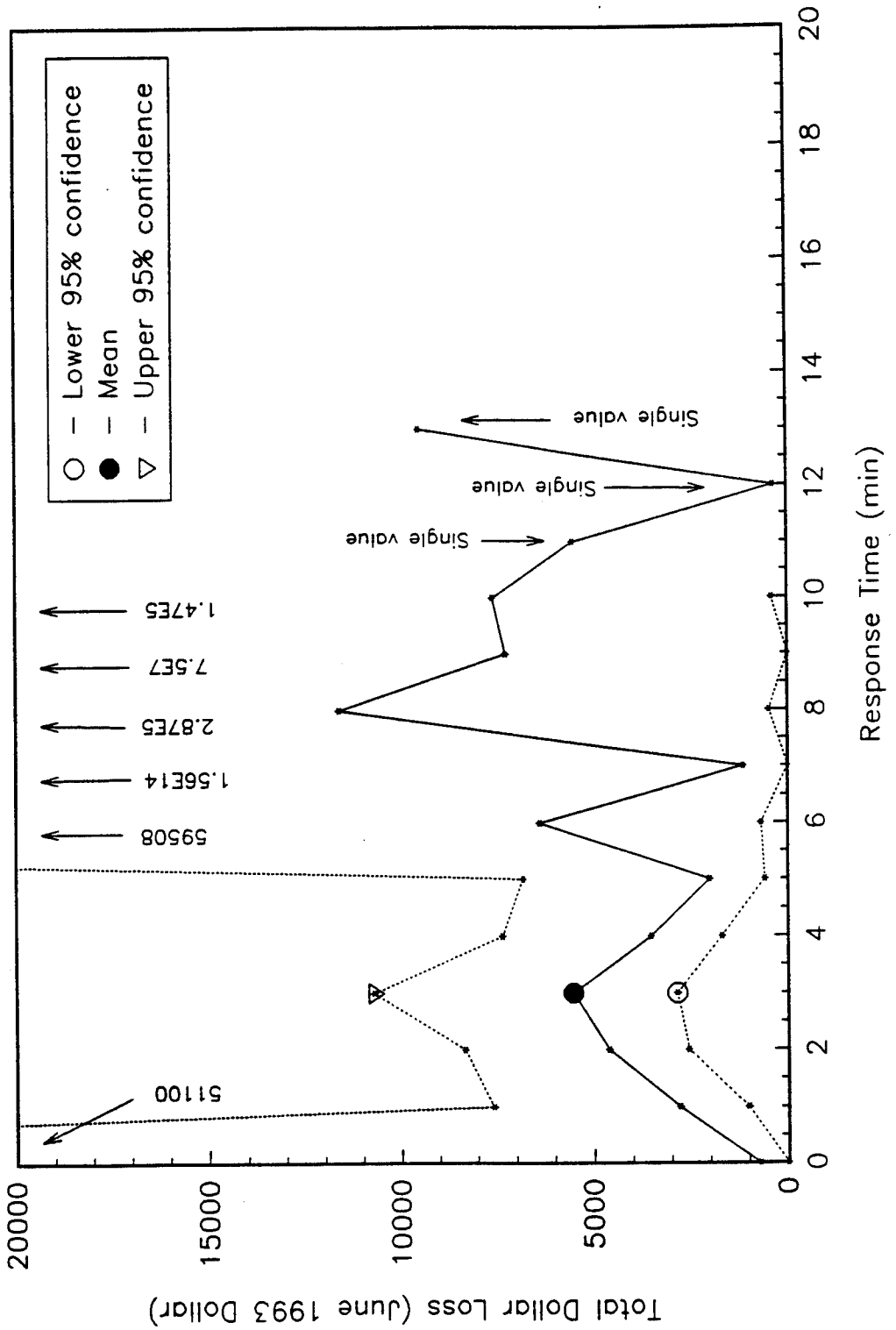


Figure 67. Effect of Response Time on Dollar Loss for Boarding Home Occupancies

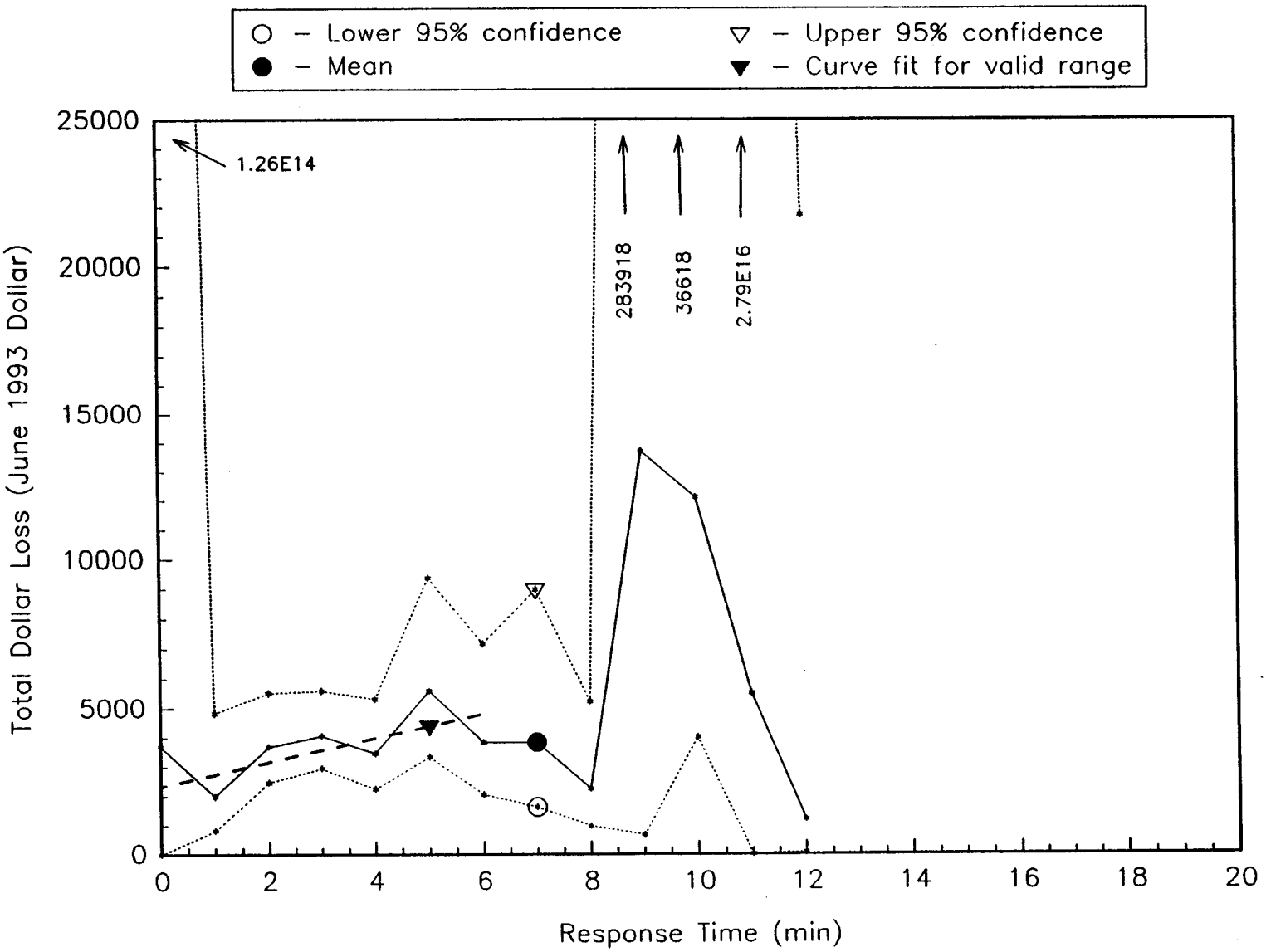


Figure 68. Effect of Response Time on Dollar Loss for Hotel Occupancies

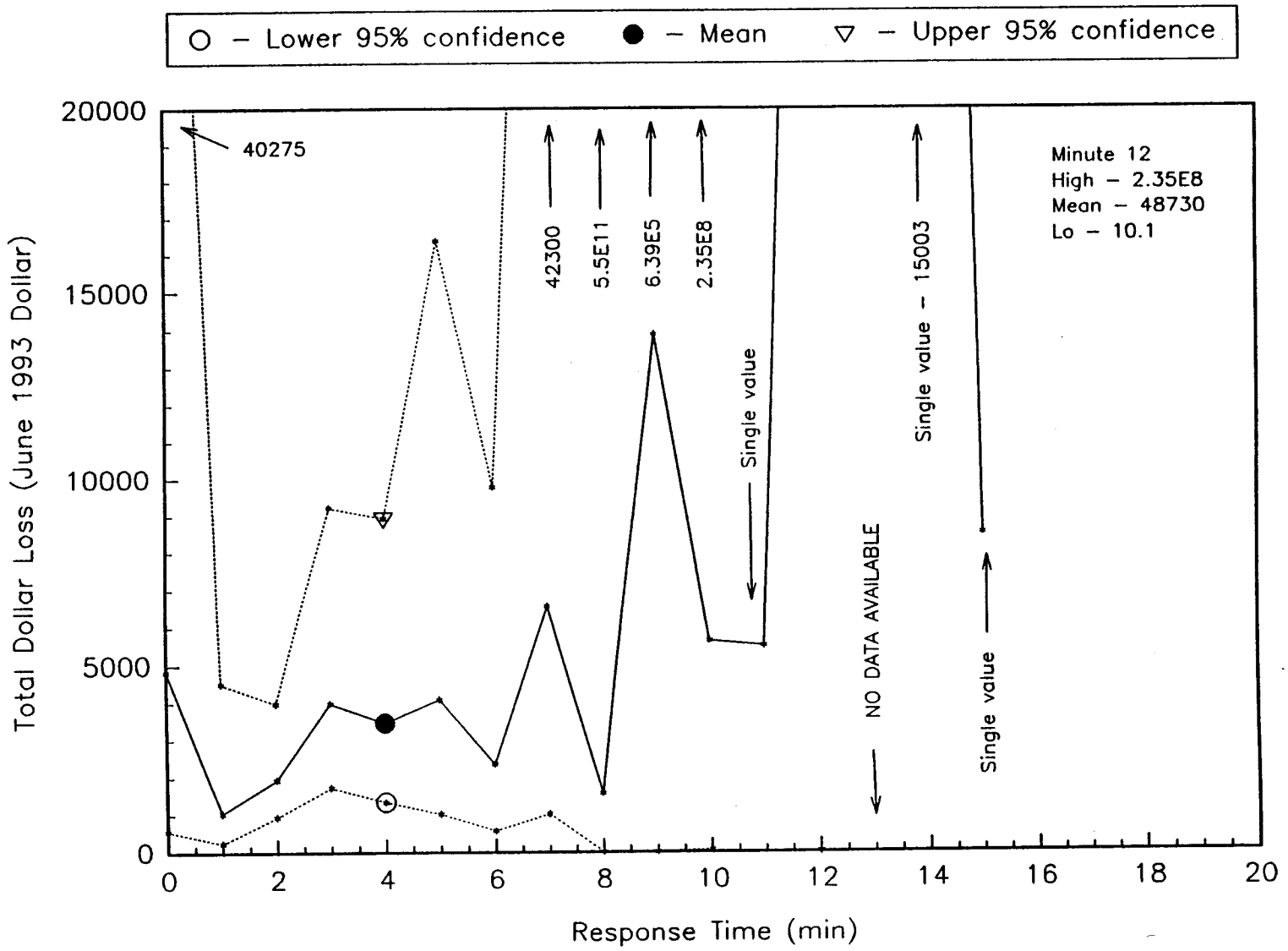


Figure 69. Effect of Response Time on Dollar Loss for Dormitory Occupancies

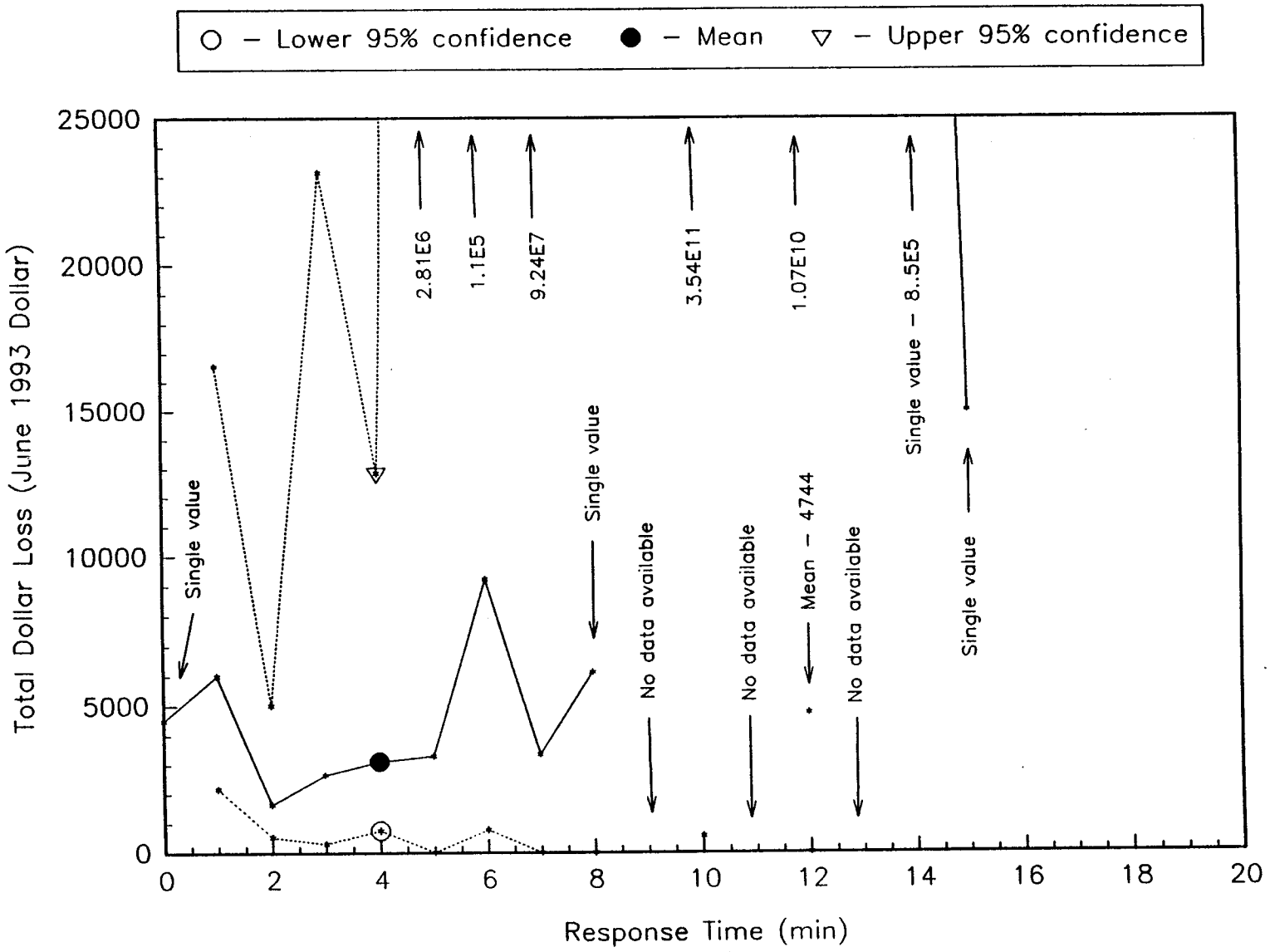


Figure 70. Effect of Response Time on Dollar Loss for Small Hotel Occupancies

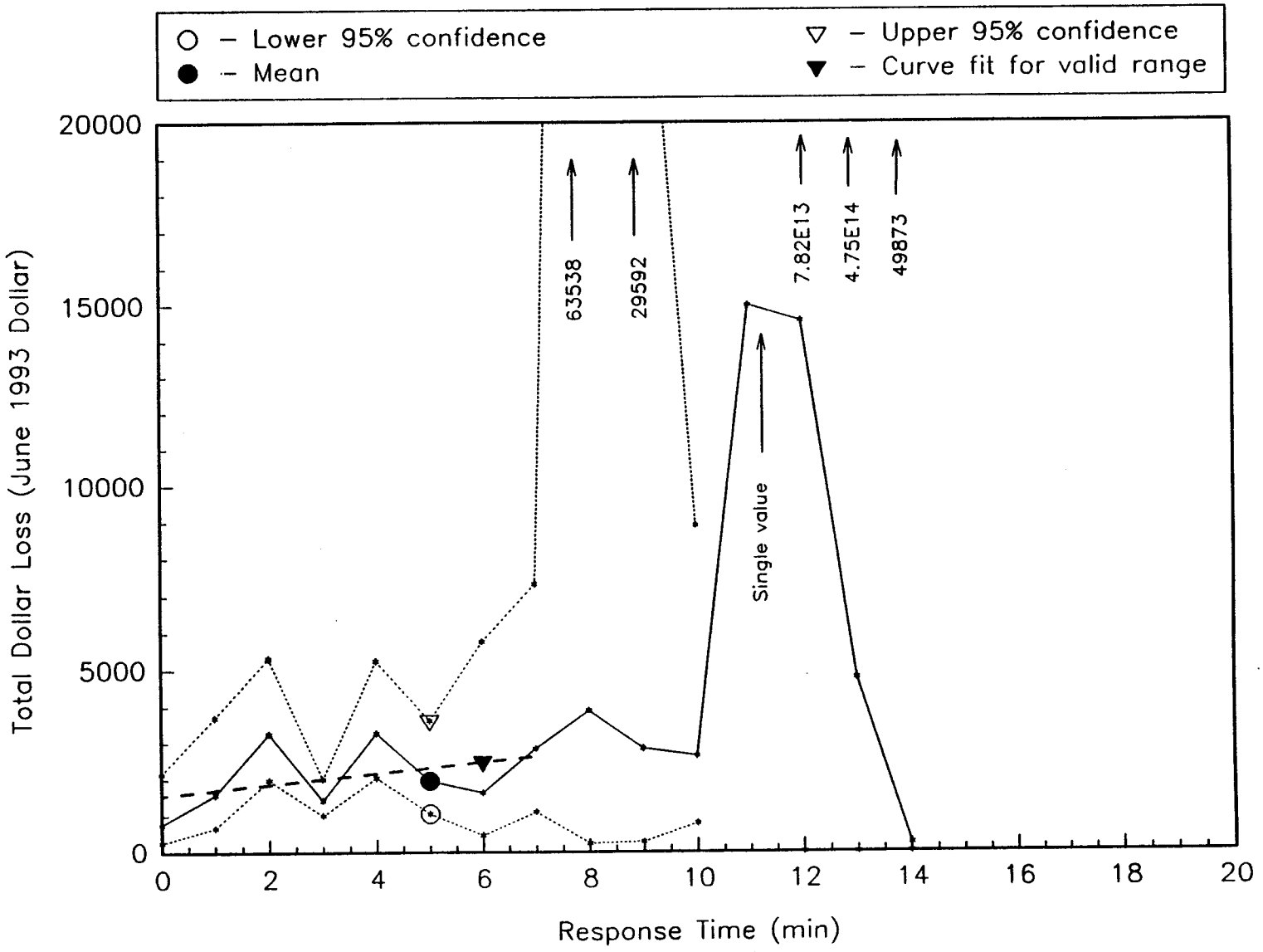


Figure 71. Effect of Response Time on Dollar Loss for Health Care Occupancies

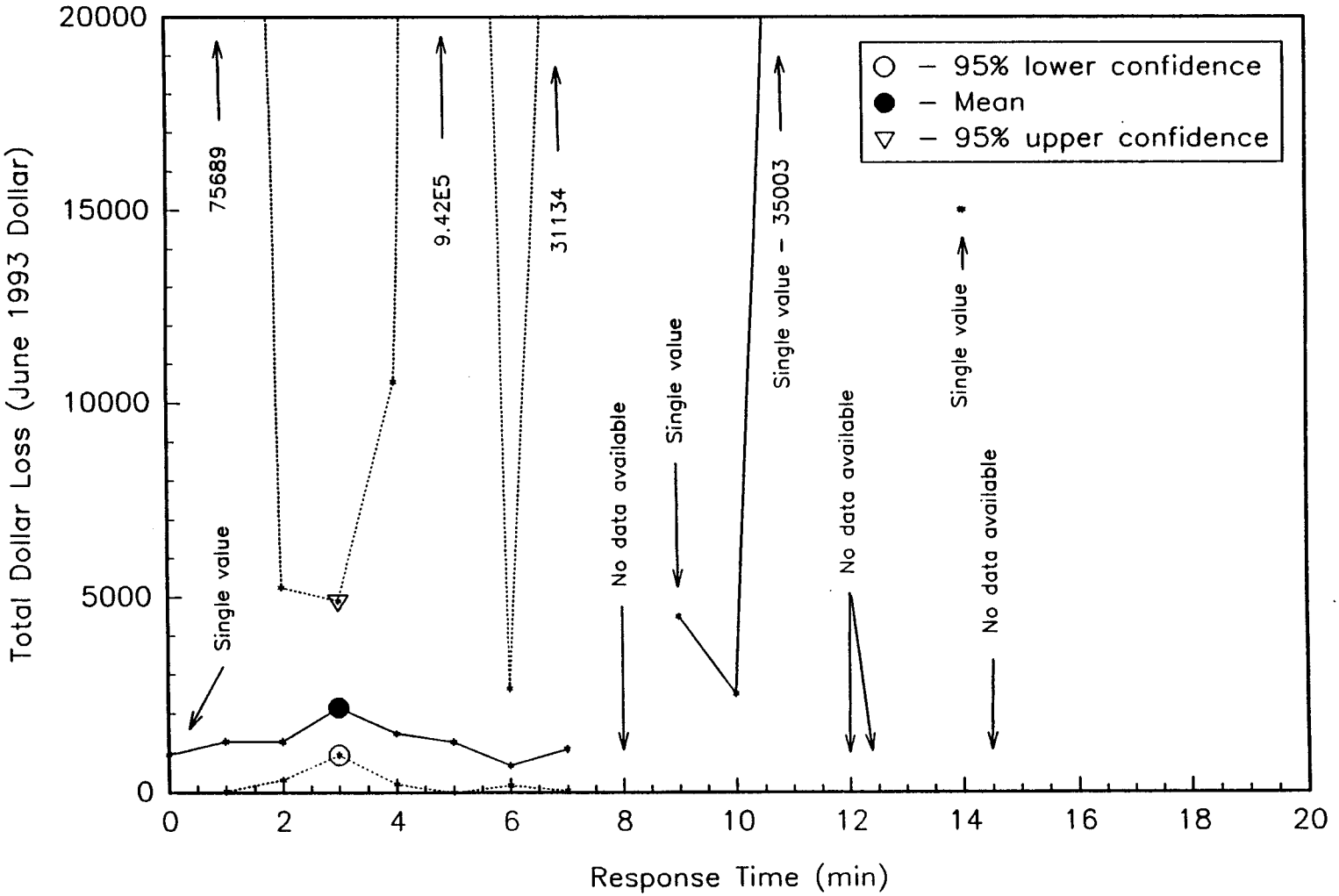


Figure 72. Effect of Response Time on Dollar Loss for Prison Occupancies

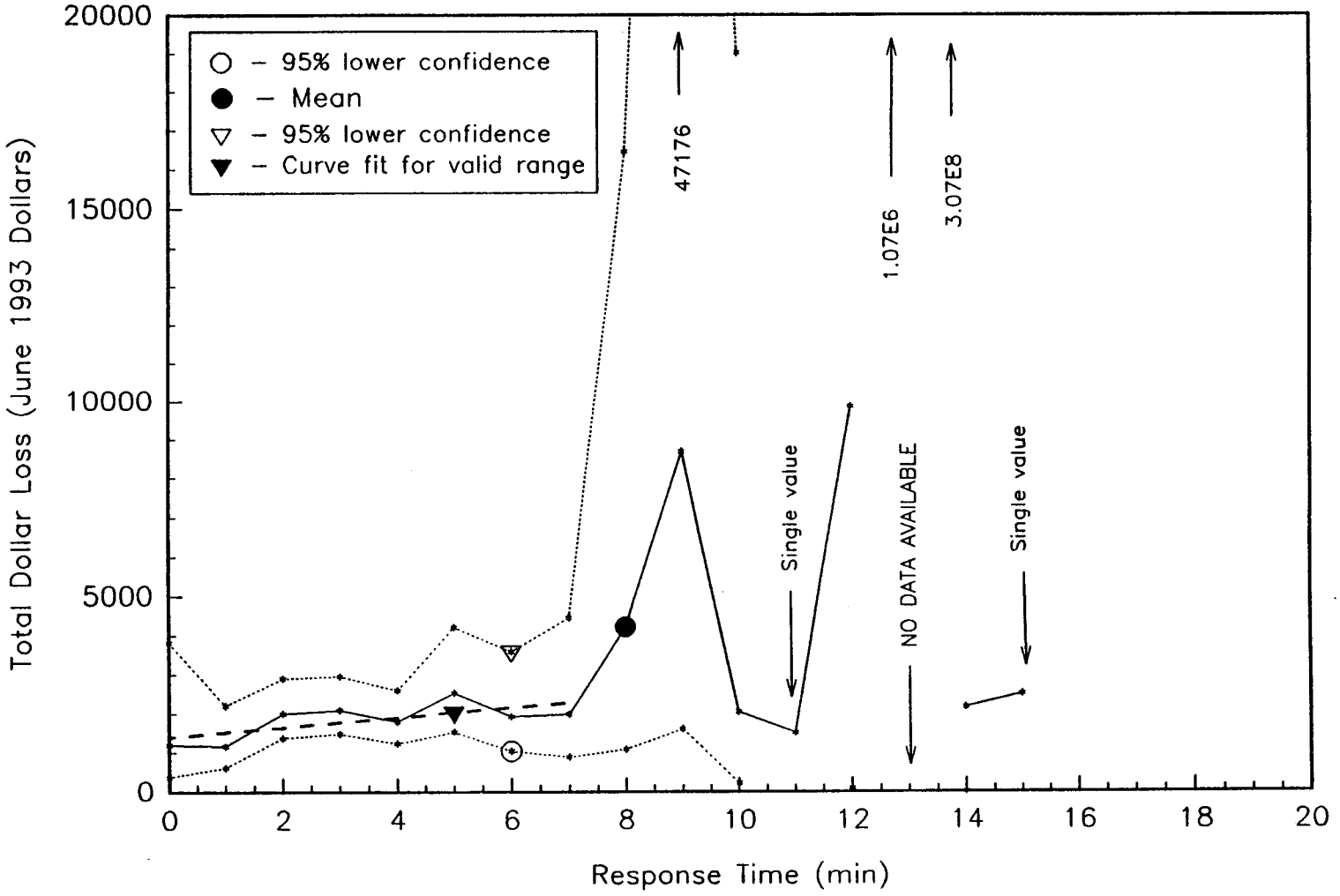


Figure 73. Effect of Response Time on Dollar Loss for Educational Property

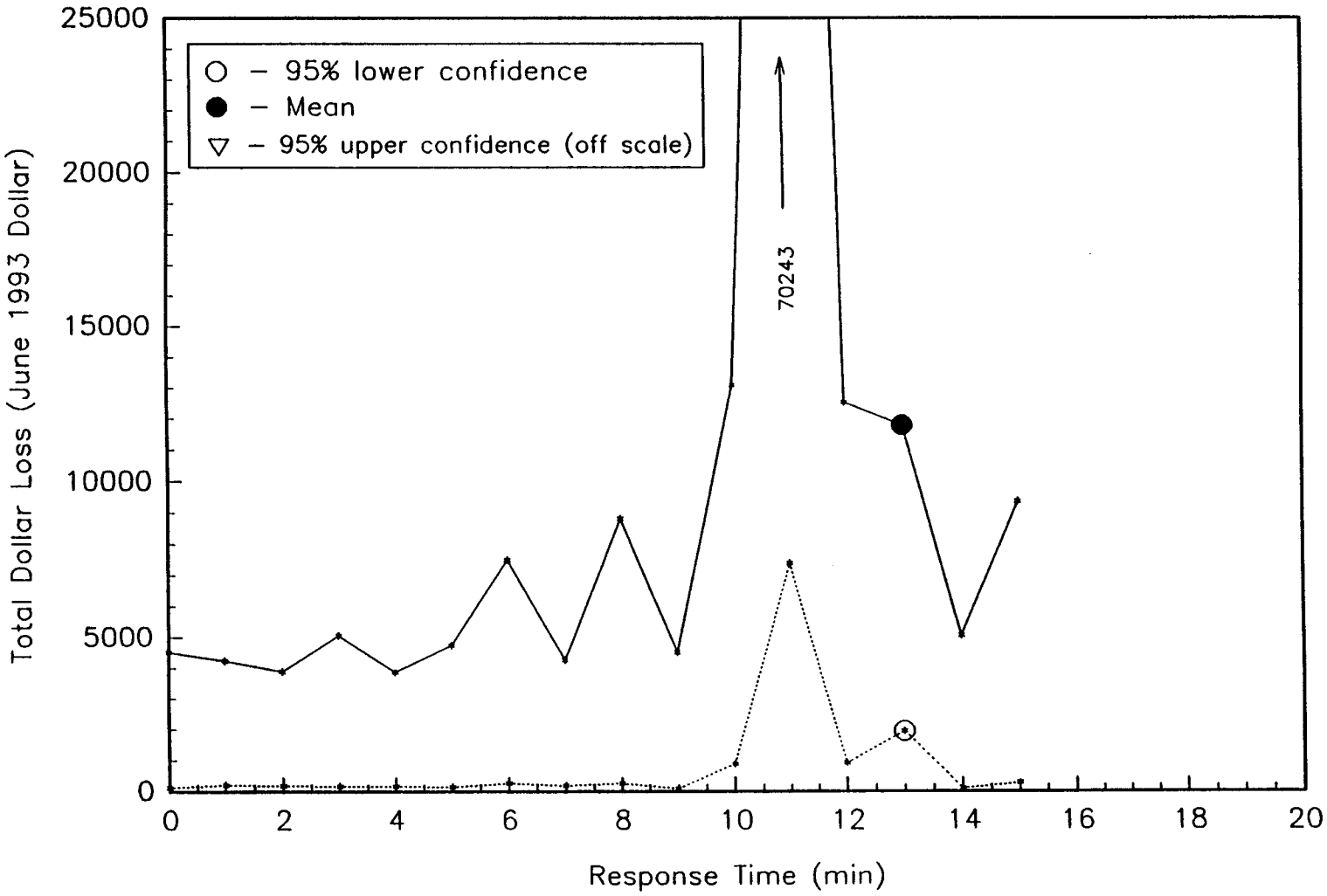


Figure 74. Effect of Response Time on Dollar Loss for Restaurants and Taverns

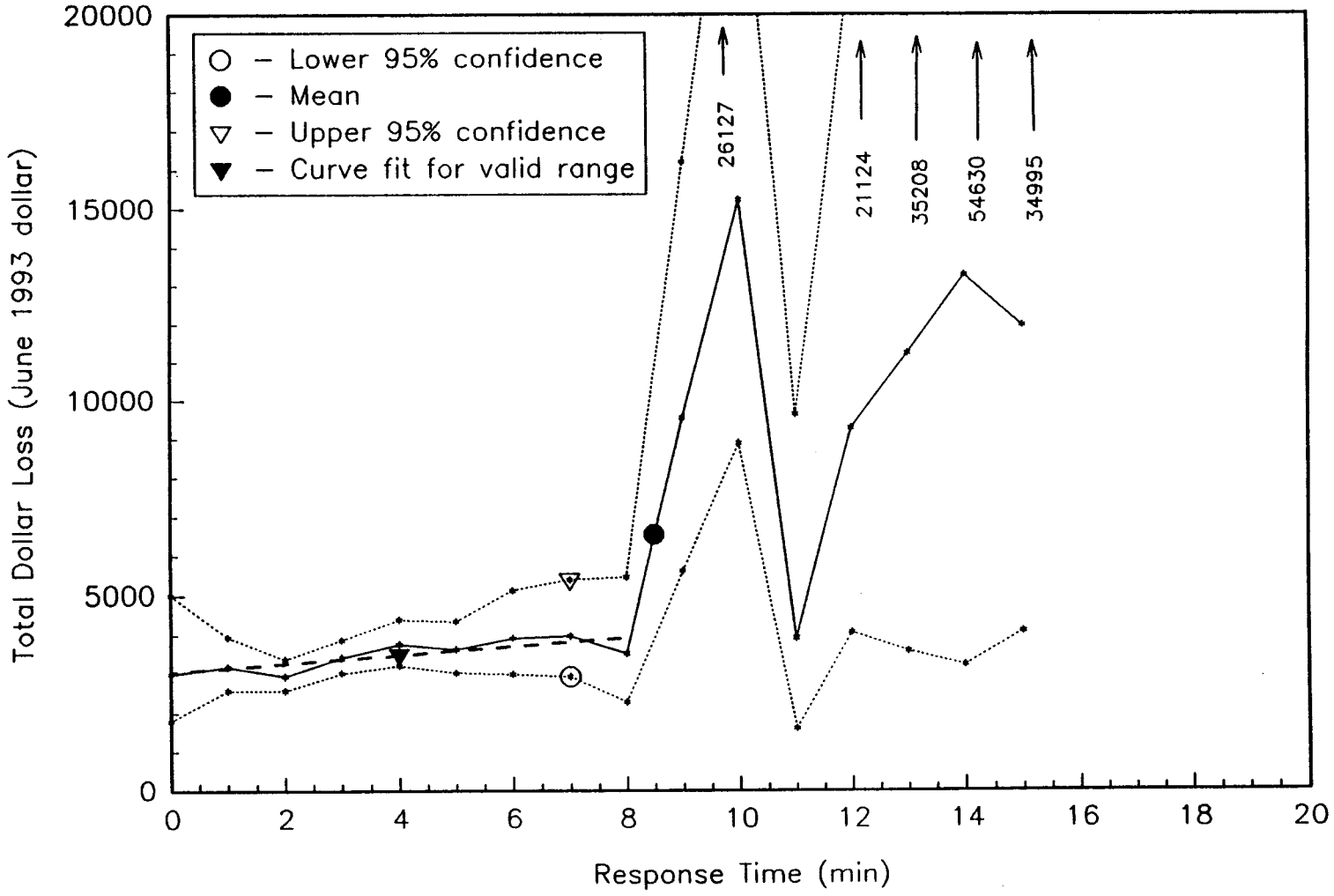


Figure 75. Effect of Response Time on Dollar Loss for Mercantile Business Occupancies

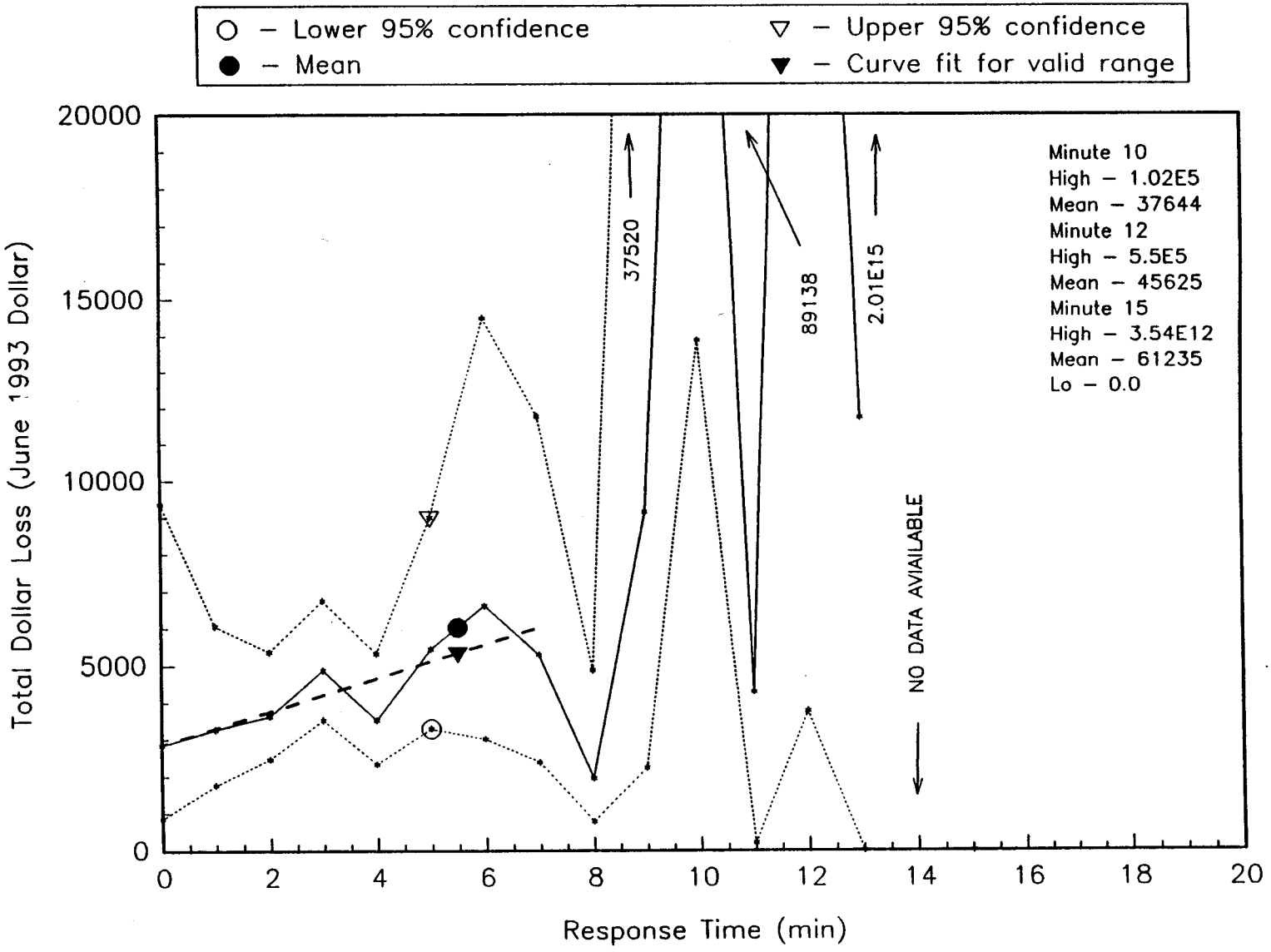


Figure 76. Effect of Response Time on Dollar Loss for Offices

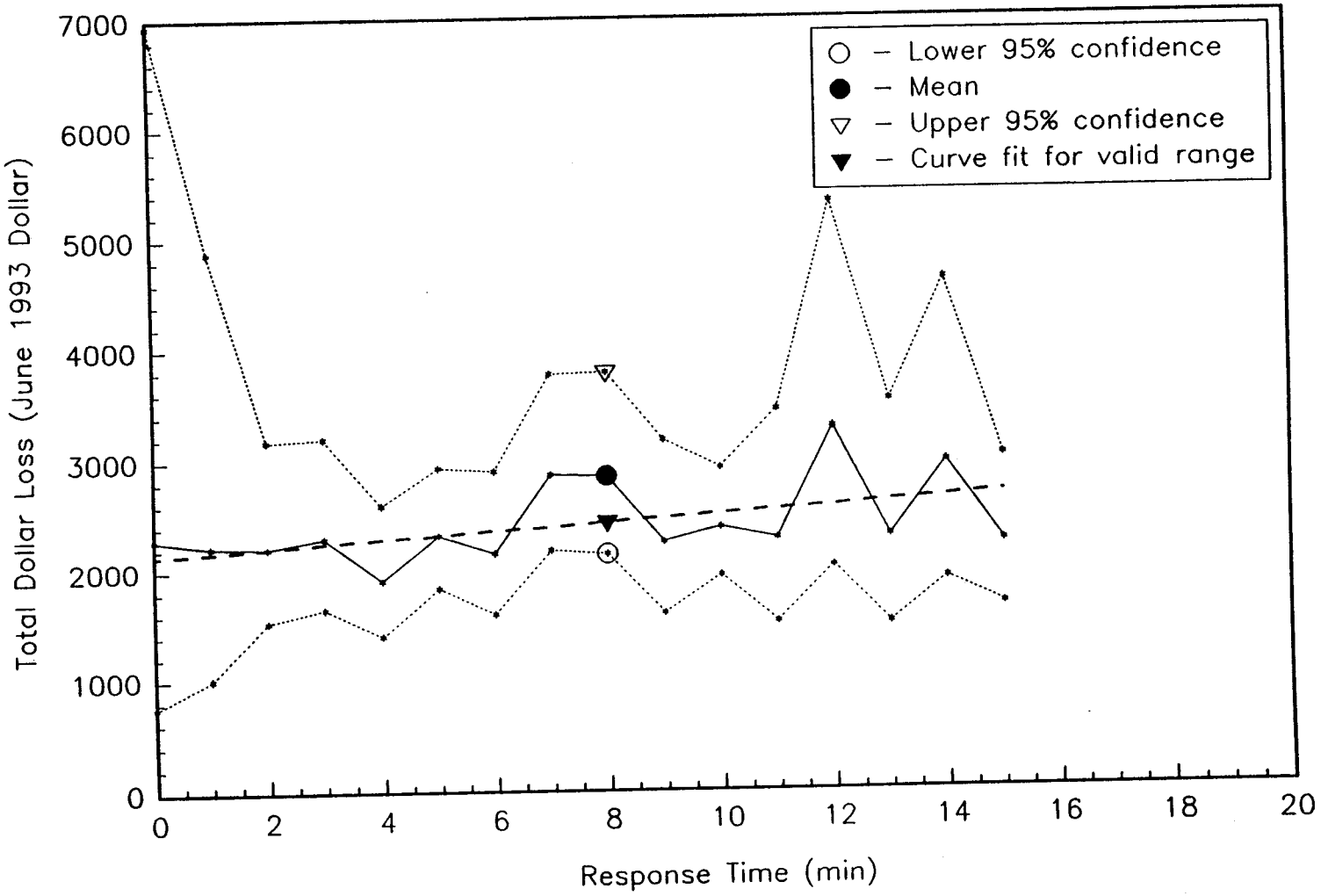


Figure 77. Effect of Response Time on Dollar Loss for Industrial and Defense Occupancies

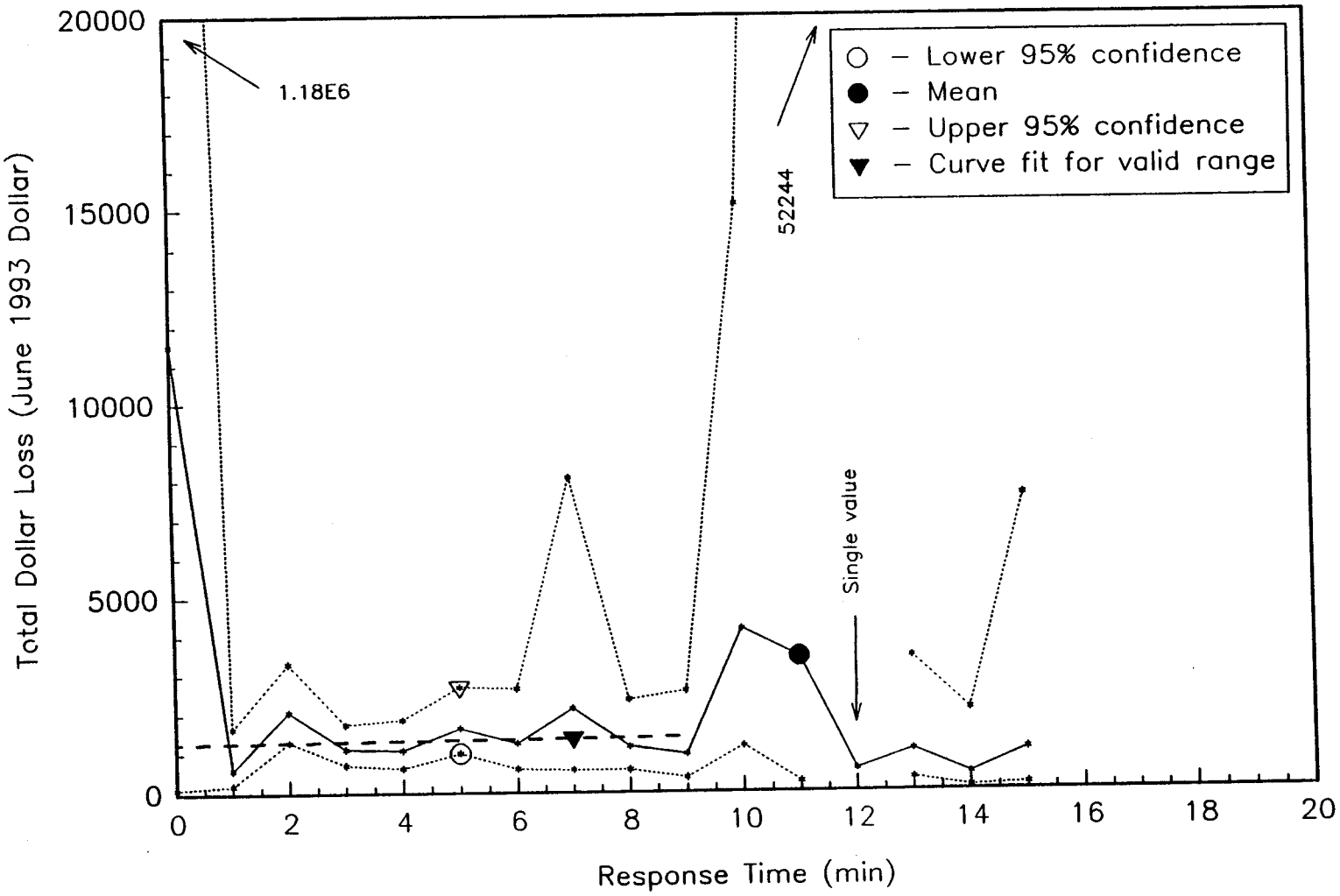


Figure 78. Effect of Response Time on Dollar Loss for Utilities/Energy Production

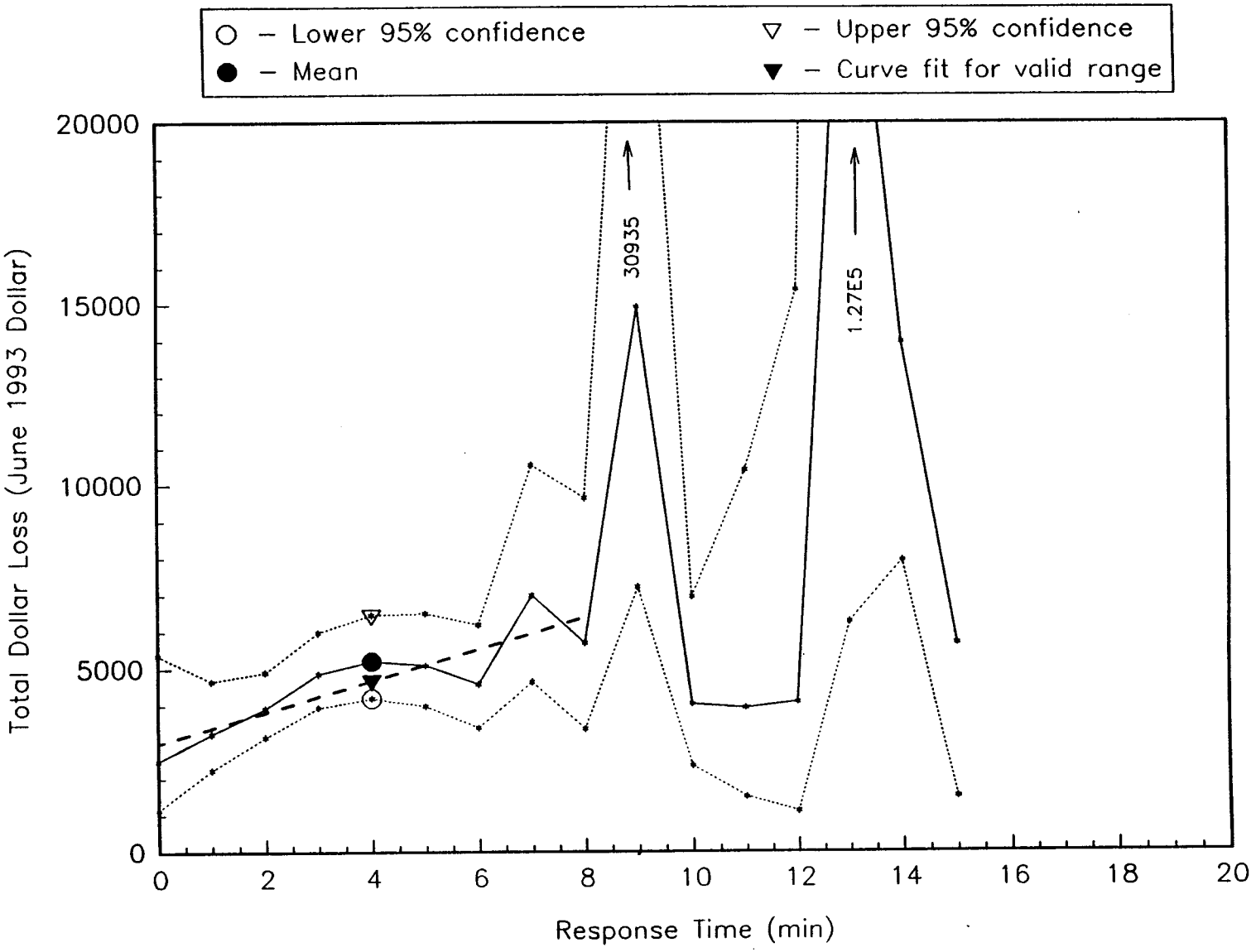


Figure 79. Effect of Response Time on Dollar Loss for Manufacturing

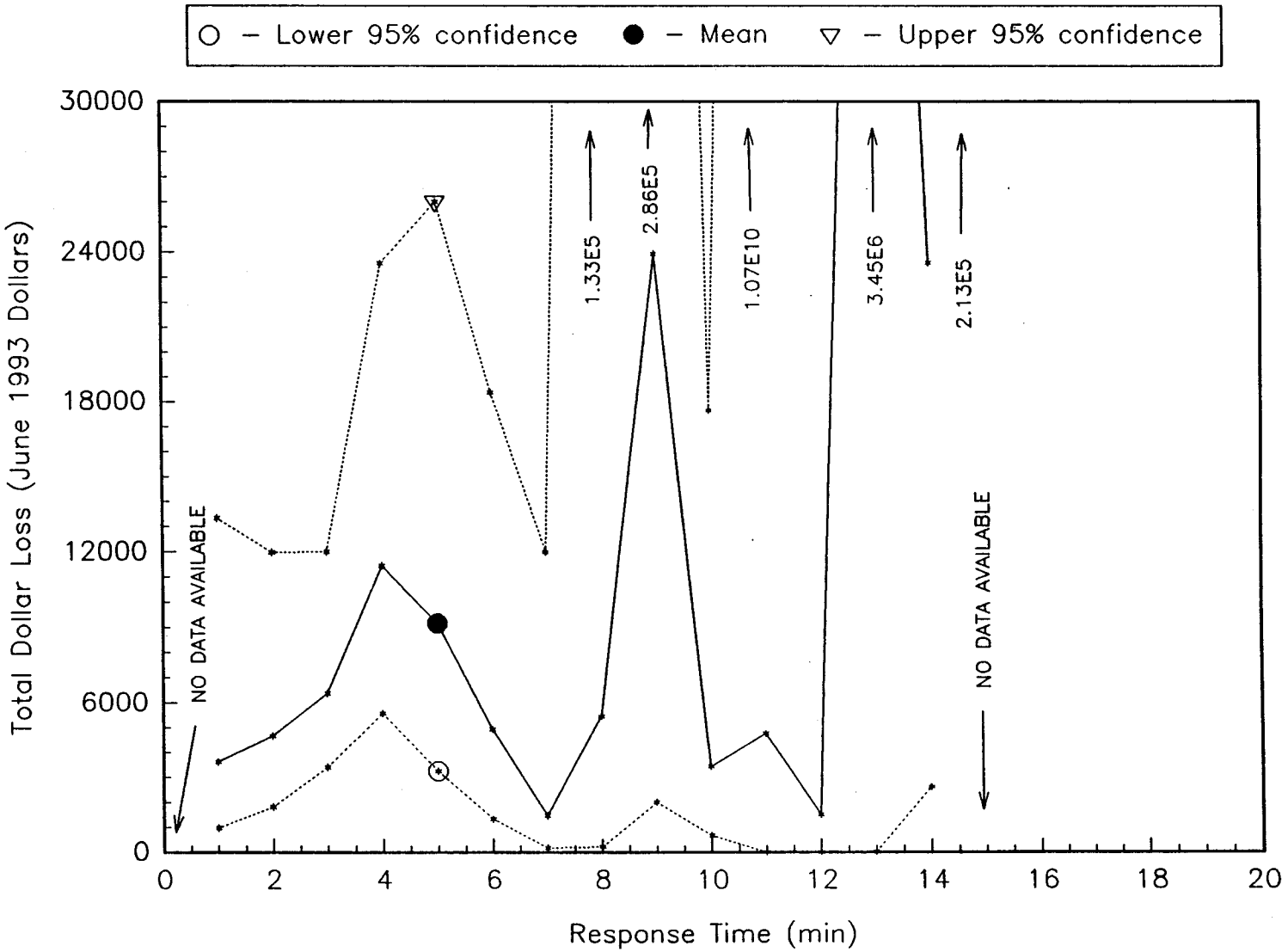


Figure 80. Effect of Response Time on Dollar Loss for Plastic, Chemical, and Petroleum Manufacturers

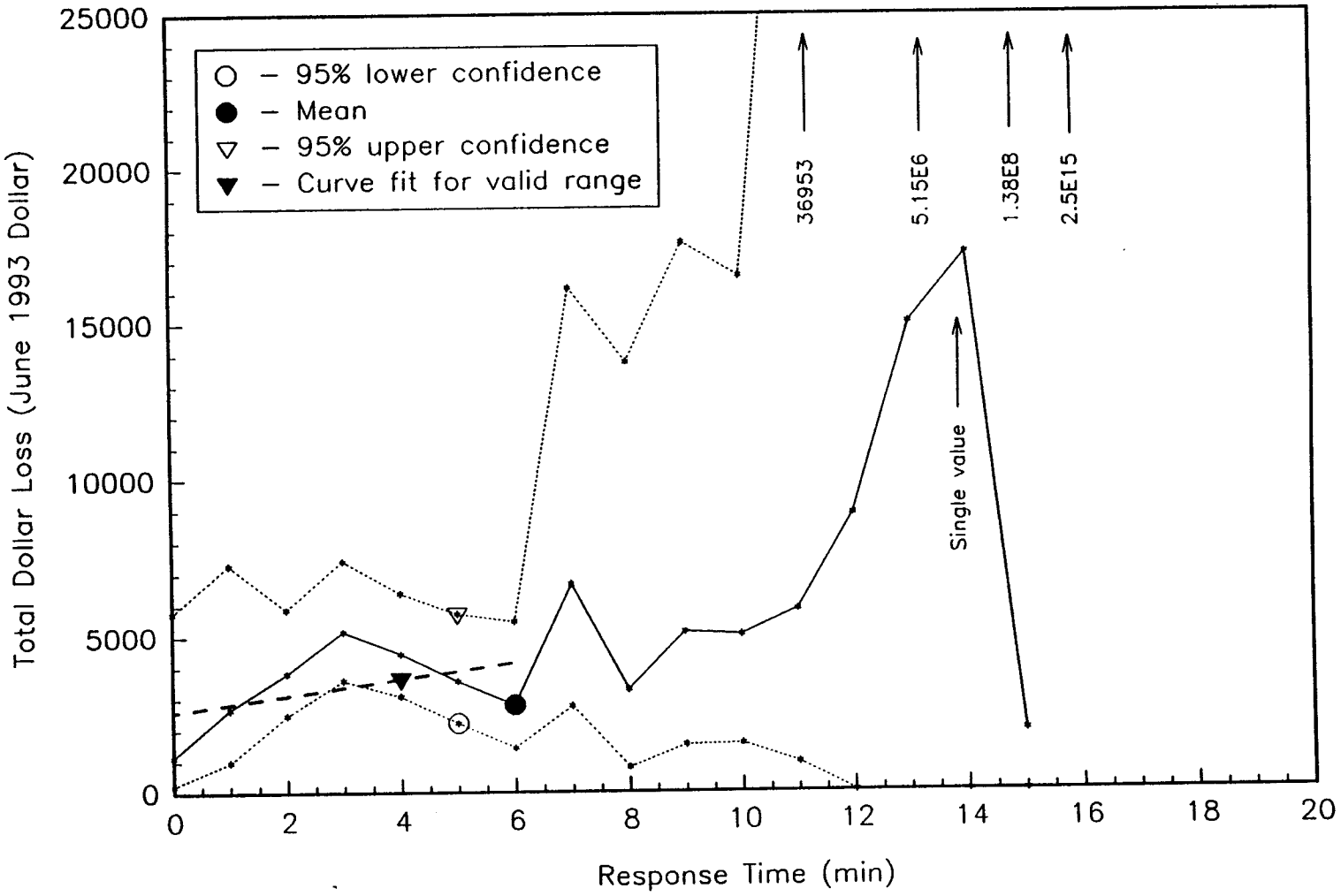


Figure 81. Effect of Response Time on Dollar Loss for Metal Production and Manufacturing

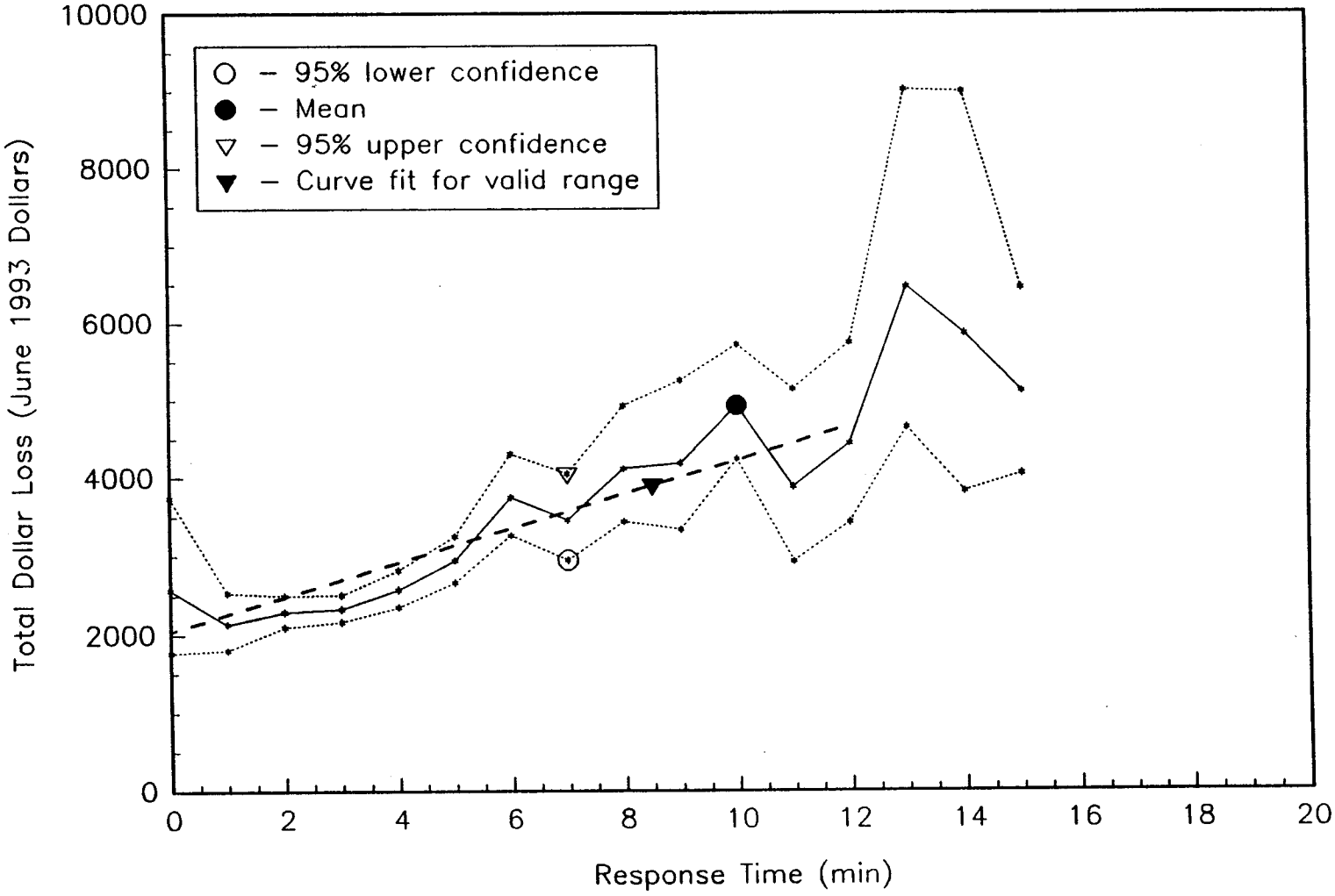


Figure 82. Effect of Response Time on Dollar Loss for Storage Occupancies

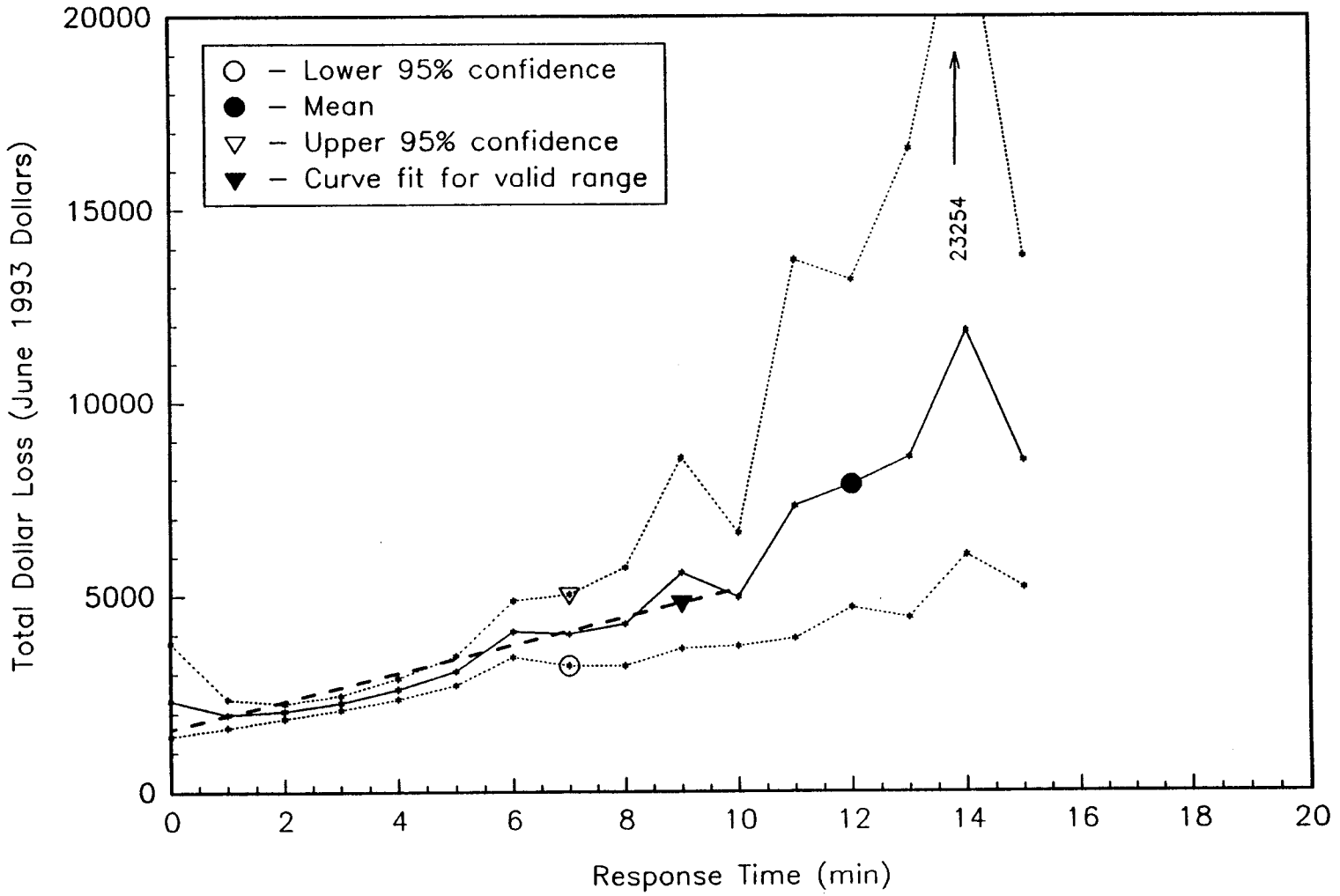


Figure 83. Effect of Response Time on Dollar Loss for Vehicle Storage Occupancies

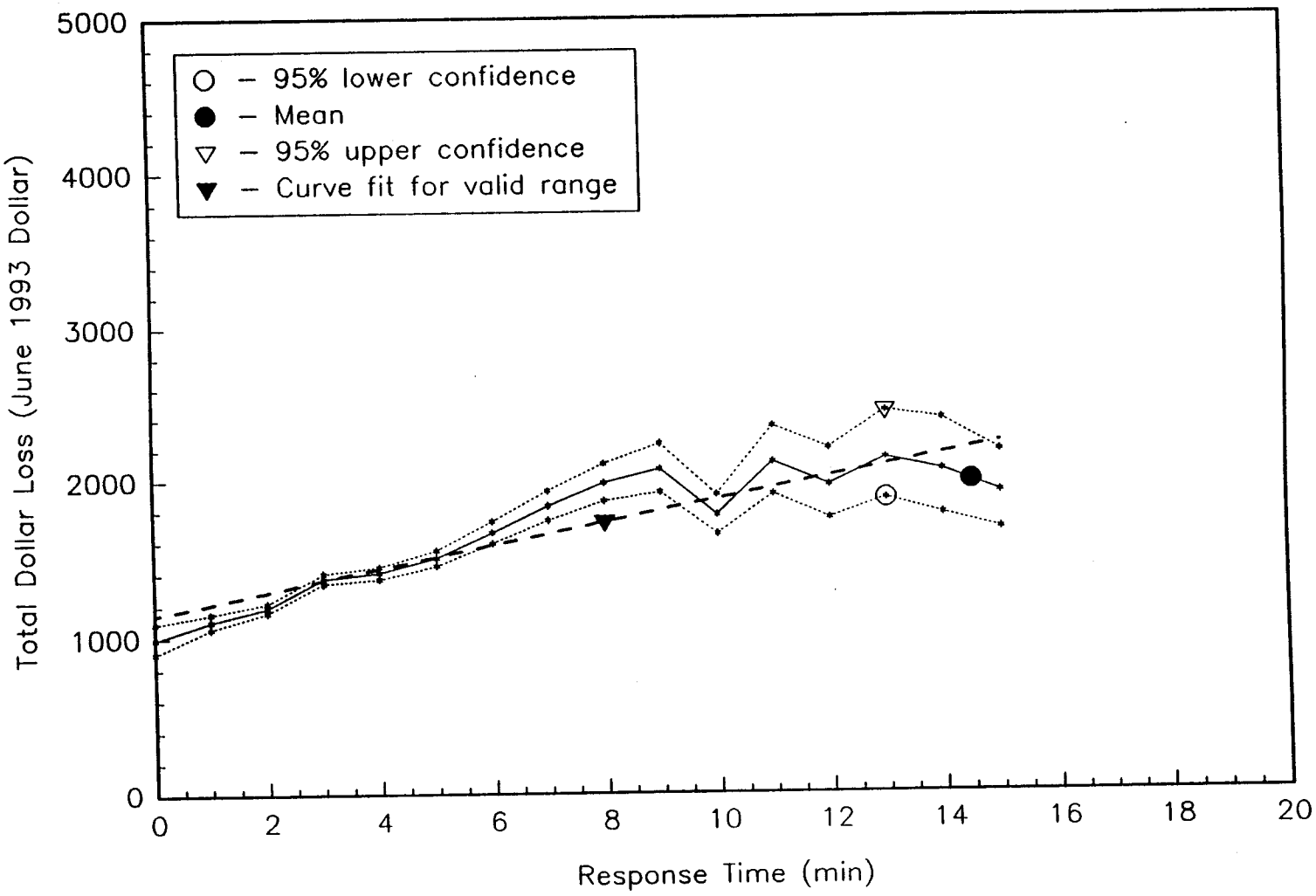


Figure 84. Effect of Response Time on Dollar Loss for Miscellaneous Special Occupancies

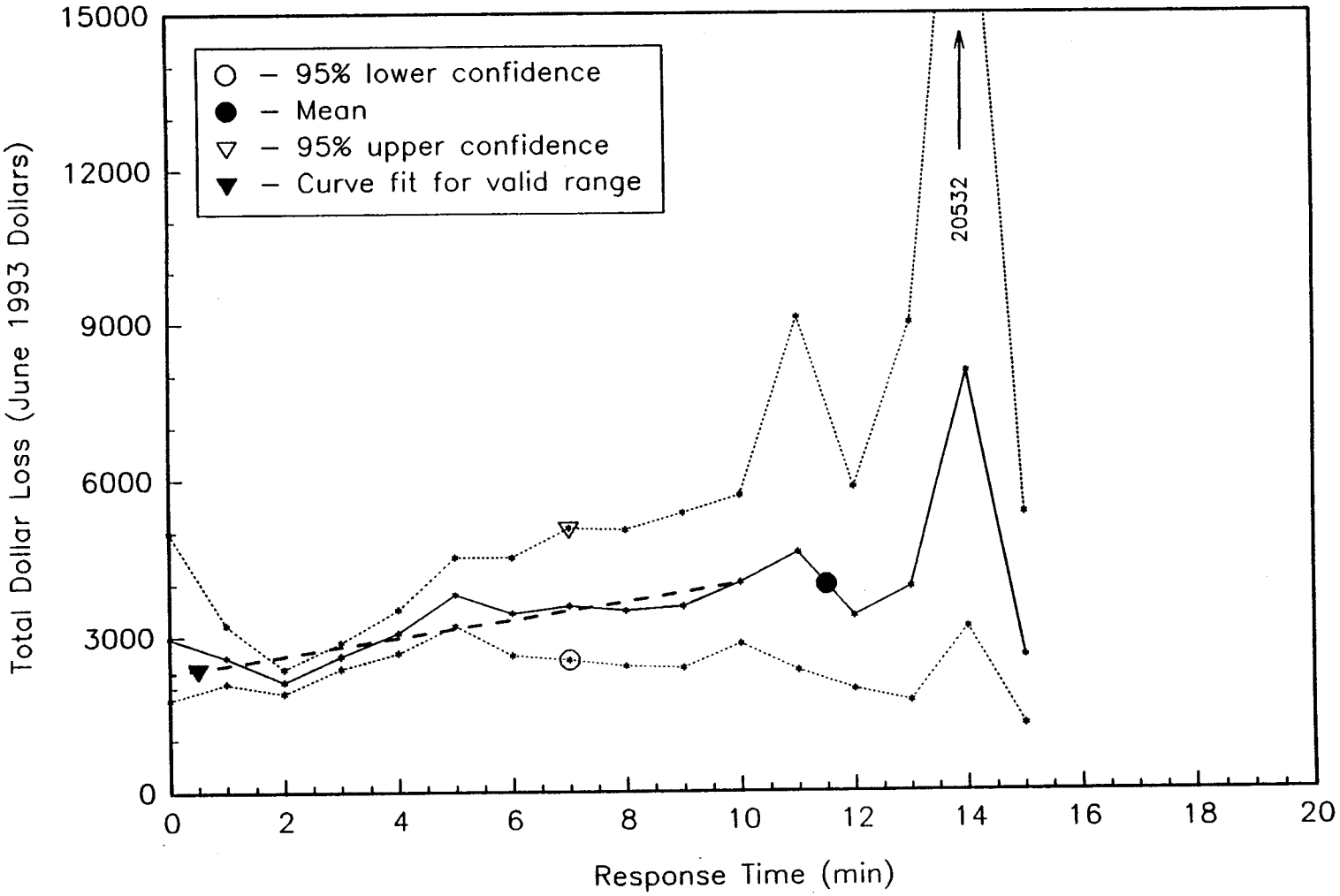


Figure 85. Effect of Response Time on Dollar Loss for Landfills

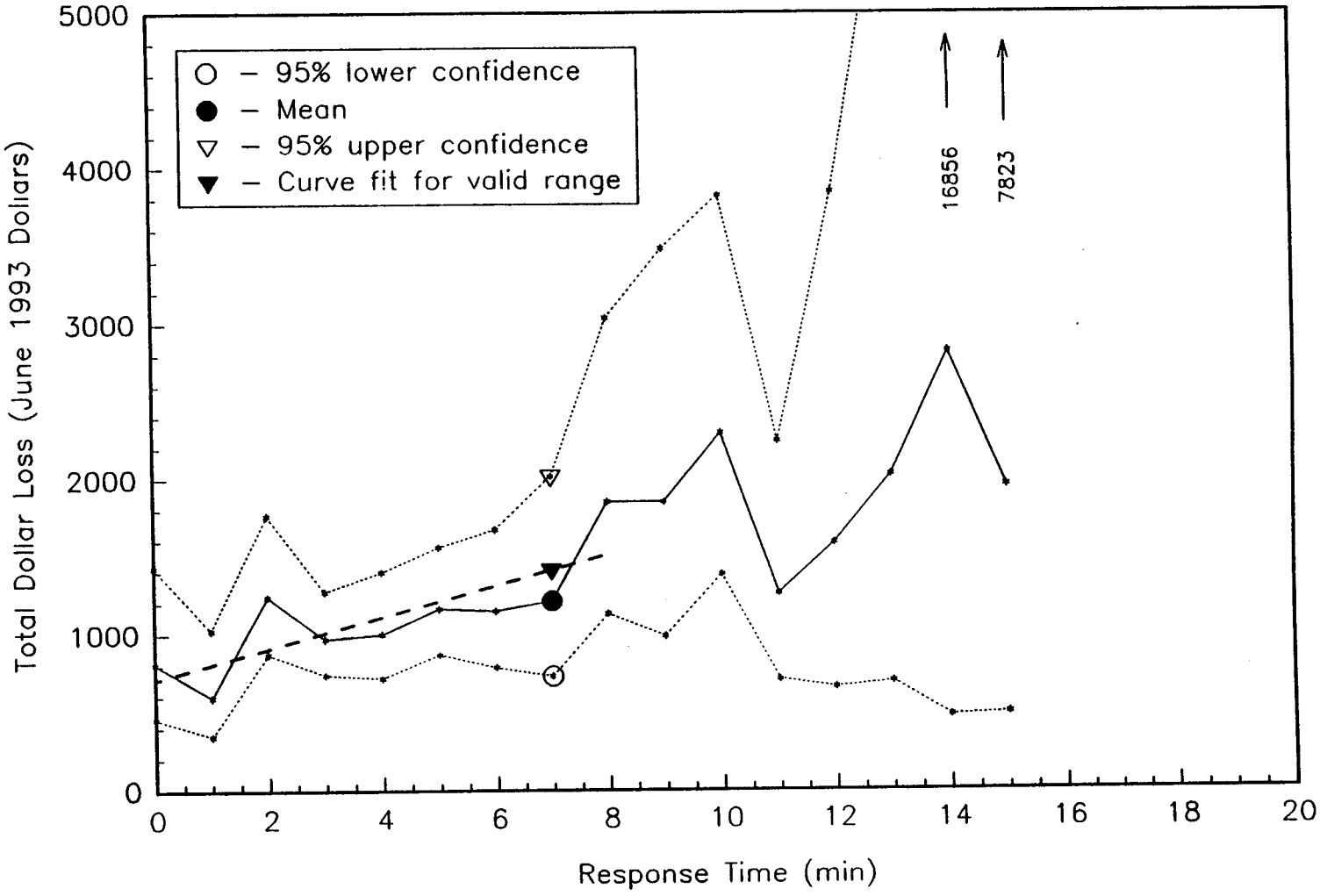


Figure 86. Effect of Response Time on Dollar Loss for Railroad Property

TABLE 10. LINEAR CURVE FIT COEFFICIENTS FOR DOLLAR LOSS VS. RESPONSE TIME

Occupancy	A ($)	B ($/min)	Range (min)
All Residential	3845	431	0 - 15
1 And 2 Family	3962	439	0 - 15
1 And 2 Family - All Year	3748	462	0 - 15
Apartments	4089	48.5	0 - 9
Hotels	2336	409	0 - 6
Health Care Facilities	1390	126	0 - 7
Educational Property	1559	151	0 - 7
Mercantile/Business Property	3045	110	0 - 8
Offices	2858	451	0 - 7
Industrial/Defence Property	2140	36	0 - 15
Utilities/Energy Production	1251	15	0 - 9
Manufacturing	2962	428	0 - 8
Metal Manufacture	2585	261	0 - 6
Storage	2047	217	0 - 11
Vehicle Storage	1594	357	0 - 10
Miscellaneous Property	1144	73	0 - 15
Landfills	2273	174	0 - 10
Railroad Property	710	100	0 - 9

2. Comparison of the NFIRS and Air Force Databases Analyses

The results of the NFIRS and Air Force database analyses were similar where the occupancies are comparable. The probability of a zero dollar loss was nearly identical between the two databases for the first 4 minutes. The NFIRS database has a higher probability of a zero dollar loss than the Air Force for response times greater than 4 minutes. The difference between NFIRS and the AF database percentage zero dollar loss incidents after the 4-minute response time may be due to the sharp decrease in incidents in the AF database at this time. The following three linear curve fit equations summarize the comparison:

$$PL = 0.49 - 0.0265 \cdot RT \quad (Air\ Force)$$
$$PL = 0.44 - 0.000582 \cdot RT \quad (NFIRS\ 0\text{-}10\ min) \qquad (4)$$
$$PL = 0.46 - 0.0026 \cdot RT \quad (NFIRS\ 0\text{-}20\ min)$$

where PL is the probability of a zero dollar loss and RT is the response time in minutes. All three correlations have similar initial probabilities. The NFIRS 0-20 minute curve fit most closely resembles the Air Force results.

The dollar loss categories that could be compared were all residential, one- and two-family dwellings, and miscellaneous properties (all fixed and mobile occupancies were not analyzed in NFIRS). For all residential and miscellaneous occupancies the results are strikingly similar, particularly for the miscellaneous occupancies. There is a larger difference between the one- and two-family occupancies which is likely due to insufficient incidents in the Air Force database (there is a single value for one of the data points in the valid curve fit range). Table 11 summarizes the comparison between the two databases.

TABLE 11. COMPARISON BETWEEN AIR FORCE AND NFIRS LINEAR DOLLAR LOSS CORRELATIONS FOR THREE OCCUPANCIES

	Air Force	NFIRS
All Residential		
A (dollars)	1995	3845
B (dollars/min)	553	431
Valid range (min)	0-6	0-15
1 and 2 family		
A (dollars)	3522	3962
B (dollars/min)	708	439
Valid range (min)	0-6	0-15
Miscellaneous		
A (dollars)	1215	1144
B (dollars/min)	180	72.8
Valid range (min)	0-7	0-15

Thus, it reasonable to assume that the results of the NFIRS analysis are applicable to Air Force bases when sufficient Air Force data are unavailable.

I. CONCLUSIONS

The following conclusions were drawn concerning the analysis of the NFIRS 1989 database analysis of the effect of response time on fire losses.

1. There was a definite correlation between the expected dollar loss and the response time for 18 different categories analyzed in the NFIRS 1989 database. All of these correlations showed that there is an increase in the expected dollar loss as the response time of the fire department increases. The correlations ranged from 15 dollars/response minute to 462 dollars/response minute with an initial dollar loss (zero minute response time) ranging from 710 dollars to 4089 dollars.

2. There was a similarity between the results of the Air Force analysis and the NFIRS analysis for categories that had a large number of incidents in the Air Force analysis. For categories with too few incidents (large confidence intervals), a comparison between the two analyses was not possible.

3. It is recommended that the results of the NFIRS response time analysis be used rather than the Air Force analysis for occupancies with insufficient USAF data due to the much larger number of incidents and improved statistical confidence which results.

SECTION V
COST MODEL

A. INTRODUCTION

The most obvious way of reducing base costs is to reduce the number of vehicles and/or the manpower. This model was developed so that users could assign their own number of vehicles and manpower to a particular base and determine the financial impact of the changes. Authorized core set information in addition to variance information is incorporated into the model as the "authorized" values. In a separate location, the user "assigns" his/her values. Information was compiled from DODI 6055.6, AFMS 4426, proposed changes for TA012 of the Aircraft Fire Protection Vehicle Sets, and Tables A19-2 and 31-2 from AFR 173-13 (References 4-7). (This information was current as of May 1993.) Further information about procurement costs and other miscellaneous items was obtained through informal communication with personnel at Wright Patterson Air Force Base and Tyndall Air Force Base.

B. EXPLANATION OF MODEL

The model is implemented in Excel and consists of a series of four user-input worksheets, three lookup tables, and two cost tables which are referenced by the worksheets, and a cost summary. These lookup and cost tables can be updated by editing the worksheet files in Excel. Below is a description of each of these sheets.

1. Worksheet 1: Vehicle Authorization Worksheet (Figure 87)

The user assigns the base he/she wants to work with at the top of this sheet. Once the base name is specified, the authorized vehicle set and variance is displayed. Then, the user may use this information to assign the desired number of vehicles to the base.

2. Worksheet 2: Manpower Authorization Worksheet (Figure 88)

This worksheet shows how many vehicles were assigned from Worksheet 1 along with the authorized number of manpower positions for each of these vehicles. The additional manpower authorized by the variances is also displayed. The user then inputs the desired number of positions per vehicle by vehicle type. The number of positions is totalled and multiplied by the Position Manpower Factor (PMF) to determine the equivalent number of shift firefighters needed.

3. Worksheet 3: Manpower Summary and Skill/Grade Distribution (Figure 89)

This sheet is divided into two sections. The upper portion allows for the number of people in Fire Operations and Management/Administration to be specified. The number of shift firefighters selected in Worksheet 2 is reflected as part of the Fire Operations total. The lower portion of the sheet displays the military grade breakdown

United States Air Force
Fire Department Cost Model

Worksheet No. 1
Vehicle Authorization Worksheet

Base Name: MACDILL AFB FL
Set No.: 2

Veh. Type	Core Set	Variances 1	2	3	4	5	6	7	8	Total
CRASH FF:										
P-2/P-23										
Auth.	1		0	0			-1			0
Assn.	2		0	0			0			2
P-4/P-19										
Auth.	2						-2	0		0
Assn.	2						0	0		2
P-15										
Auth.	0								0	0
Assn.	0								0	0
P-13/P-20										
Auth.	2									2
Assn.	2									2
RESCUE:										
P-10										
Auth.	1									1
Assn.	1									1
TANKER:										
P-18/P-26										
Auth.	1									1
Assn.	1									1
PUMPERS:										
P-27										
Auth.	0									0
Assn.	0									0
P-8/P-22										
Auth.	1									1
Assn.	0									0
P-12/P-24										
Auth.	1	0								1
Assn.	1	0								1
LADDERS:										
P-21										
Auth.	0									0
Assn.	0									0

Figure 87. Vehicle Authorization Worksheet

United States Air Force
Fire Department Cost Model

Worksheet No. 2
Manpower Authorization Worksheet

Base Name: MACDILL AFB FL
Set No. 2
2.69 - Position Manpower Factor (PMF)

Veh. Type	Core Set	Variances 1	2	3	4	5	6	7	P-15	Total Posit.
CRASH FF:										
P-2/P-23										
Assn. # Veh.	2		0	0			0			
Auth. Pos/Veh	3		0	0			0			6
Assn. Pos/Veh	3		0	0			0			6
P-4/P-19										
Assn. # Veh.	2						0	0		
Auth. Pos/Veh	3						-5	0		6
Assn. Pos/Veh	3						0	0		6
P-15										
Assn. # Veh.	0								0	
Auth. Pos/Veh	0								0	0
Assn. Pos/Veh	0								0	0
P-13/P-20										
Assn. # Veh.	2									
Auth. Pos/Veh	2									4
Assn. Pos/Veh	2									4
RESCUE:										
P-10										
Assn. # Veh.	1									
Auth. Pos/Veh	3									3
Assn. Pos/Veh	3									3
TANKER:										
P-18/P-26										
Assn. # Veh.	1									
Auth. Pos/Veh	0									0
Assn. Pos/Veh	1									1
PUMPERS:										
P-27										
Assn. # Veh.	0									
Auth. Pos/Veh	0									0
Assn. Pos/Veh	0									0
P-8/P-22										
Assn. # Veh.	0									
Auth. Pos/Veh	0									0
Assn. Pos/Veh	0									0
P-12/P-24										
Assn. # Veh.	1	0								
Auth. Pos/Veh	4	0								4
Assn. Pos/Veh	4	0								4
LADDER:										
P-21										

Figure 88. Manpower Authorization Worksheet

Assn. # Veh.	0		
Auth. Pos/Veh	0		0
Assn. Pos/Veh	0		0
		Total Positions	24
		X PMF	2.69
		Total Assigned Manpower	65

Figure 88. Manpower Authorization Worksheet (concluded)

United States Air Force
Fire Department Cost Model

Worksheet No. 3
Manpower Summary and Skill\Grade Distribution

Base Name : MACDILL AFB FL
Set No. : 2

MANPOWER ASSIGNMENT SUMMARY	Auth.	Assigned
Fire Operations		
Shift Firefighters	62	65
Communications	5	5
Investigators/Insp.	2	2
Fire Operations Totals	69	72
Mgmt./Admin.		
Fire Chief	1	1
AC of O&R	1	1
AC Ops.	2	2
Training NCO	1	1
Information Mgmt.	1	1
Mgmt./Admin. Totals	6	6
Overall Total	75	78

MILITARY GRADE DISTRIBUTIONS (Based on assn. manpower totals)

Core Set Reqmts.	Assigned 78	E-9 1	E-8 1	E-7 3	E-6 8	E-5 15	E-4 23	E-3 27
Mgmt./Admin.								
Fire Chief		1						
AC of O&R			1					
AC Ops.				1				
Training NCO					4			
Information Mgmt.				2				
Subtotal		1	1	3	4	0	0	0
Operations								
Shift FF					4	13	22	27
Comm.						2		
Insp./Edu.							1	
Subtotal		0	0	0	4	15	23	27
Total Assigned by Grade		1	1	3	8	15	23	27

Figure 89. Manpower Summary and Skill/Grade Distribution Worksheet

of the total manpower figure from the upper portion. The user may use this as a guideline to assign the grade breakdown.

4. Worksheet 4: Military Enlisted/General Schedule (GS) Pay Grade Equivalency Worksheet (Figure 90)

This sheet is necessary since not all base employees are not enlisted in the military. Therefore, an employee's pay will depend on whether he/she is a civilian or enlisted. It is usually assumed that 60% of a base is enlisted and 40% is civilian. However, the cost model allows these percentages to be changed. In this worksheet, the user can specify the GS Grade which is equivalent to each Military Grade for both Fire Operations positions as well as Management/Administration.

5. Lookup Table 1: List of Bases with Vehicle Set No. and Variances (Figure 91)

This table is referenced by Worksheets 1 and 2, and includes all domestic bases with core vehicle set information and variance information.

6. Lookup Table 2: Vehicle Allocations (Figure 92)

This table specifies the number of vehicles in each ARFF vehicle set.

7. Lookup Table 3: Standard Manpower Table (Figure 93)

This table lists the standard breakdown of a crew by military grade based on the total crew size.

8. Cost Table 1: Vehicle Replacement and Overhaul Costs Table (Figure 94)

This table lists the annual cost of each vehicle type based on the replacement value and the expected lifetime. Where applicable, overhaul costs are included. (Procurement figures were obtained from Wright Patterson Air Force Base).

9. Cost Table 2: Manpower Cost Factors Lookup Table (Figure 95)

This table includes the annual manpower costs for both military and civilian personnel. These figures are based on the base pay, retirement funding, and other miscellaneous costs found in Tables A19-2 and 31-2 in AFR 173-13 (Reference 7).

10. Cost Analysis Summary (Figure 96)

This sheet is a summary of the information entered for the base. Page 1 is a list of the number of each vehicle type assigned as well as the number of positions assigned to them. This list represents the information from Worksheets 1 and 2. The second page details the manpower data (i.e. how many people were assigned and the

United States Air Force
Fire Department Cost Model

Worksheet No. 4
Military Enlisted/General Schedule (GS)
Pay Grade Equivalency Worksheet

Base Name : MACDILL AFB FL
ARFF Set: 2

Military Enlisted Grade	Associated GS Grade			
	Fire Operations		Mgmt./Admin.	
	Auth.	Assn.	Auth.	Assn.
E-9			12	12
E-8			11	11
E-7			10	10
E-6	8	8	9	9
E-5	7	7	8	8
E-4	6	6	7	7
E-3	5	5		

Military/Civilian Combination Ratios (Total=1.0)
Military 0.6 Civilian 0.4

Figure 90. Military/General Schedule Pay Grade Equivalency Worksheet

Lookup Table #1
LIST OF BASES WITH VEH. SET # AND VARIANCES

Base Name	Set #	Var. 1	Var. 2	Var. 3	Var. 4
ACADEMY	2	21.52	0	0	6
AL JHARJ SAUDI	2	0	0	0	0
ALCONBURY RAF UK	2	21.52	0	0	0
ALPENA MI	2	0	0	0	0
ALTUS AFB OK	3	0	8.07	0	0
ANCHORAGE AK	2	0	0	0	0
ANDERSON AFB GU	3	10.76	8.07	0	2.69
ANDREWS AFB MD	3	10.76	0	5.38	0
ARNOLD AFS TN	3	0	0	0	0
AVIANO AB IT	3	10.76	0	0	0
BALTIMORE MD	2	0	0	0	0
BANGOR IAP ME	3	0	0	0	0
BARKSDALE AFB LA	3	10.76	0	5.38	0
BARNES APT MA	2	0	0	0	0
BEALE AFB CA	3	21.52	0	5.38	0
BERGSTROM AFB TX	2	0	0	0	0
BIRMINGHAM APT AL	2	0	0	0	0
BITBURG AB GE	2	10.76	0	0	0
BOISE APT ID	2	0	0	0	0
BRADLEY AND CT	2	0	0	0	0
BRIDGTOWN MO	2	0	0	0	0
BUCKLEY ANG CO	2	0	0	0	0
BURLINGTON IAP VT	2	0	0	0	0
BYRD FLD VA	2	0	0	0	0
CAMP DOUGLAS WI	3	0	0	0	0
CANNON AFB NM	2	10.76	0	0	10.76
CAPITAL APT IL	2	0	0	0	0
CARSWELL AFB TX	2	0	0	0	0
CASTLE AFB CA	3	0	0	0	0
CHARLESTON AFB SC	3	0	0	5.38	0
CHARLOTTE ANG NC	2	0	0	0	0
CHEYENNE MAP WY	2	0	0	0	0
CHICAGO-OHARE	2	0	0	0	0
COLORADO SPRINGS	2	0	0	0	0
COLUMBUS AFB MS	1	0	0	0	7
DANELLY ANG AL	2	0	0	0	0
DAVIS MONTHAN AZ	2	21.52	0	5.38	0
DES MOINES MAP IA	2	0	0	0	0
DIYARBAKIR AS	2	0	0	0	0
DOBBINS AFB GA	3	0	0	0	0
DOVER AFB DE	3	10.76	0	5.38	0
DULUTH MN	2	0	0	0	0
DYESS AFB TX	3	10.76	0	5.38	0
EDWARDS AFB CA	3	32.28	5.38	5.38	0
EGLIN AFB FL	3	43.04	21.52	0	2.69
EIELSON AFB AK	3	10.76	0	5.38	6
ELLINGTON AFB TX	2	0	0	0	0
ELLSWORTH AFB SD	3	10.76	0	5.38	0
ELMENDORF AFB AK	3	32.28	8.07	0	0
FAIRCHILD AFB WA	3	0	0	5.38	0
FAIRFORD RAF UK	3	0	0	0	0

Figure 91. Table of Bases with Associated Vehicle Set Number and Variance Information

FRESNO APT CA	2	0	0	0	0
FT SMITH MAP AF	2	0	0	0	0
FT WAYNE MAP IN	2	0	0	0	0
GARDEN CITY GA	2	0	0	0	0
GRAND FORKS ND	3	0	8.07	5.38	0
GREAT FALLS IAP	2	0	0	0	0
GREATER PEORIA APT IL	2	0	0	0	0
GREATER PITTSBURGH IAP PA	3	0	0	0	0
GREATER WILMINGTON APT DE	2	0	0	0	0
GRIFFIS AFB NY	3	0	0	5.38	0
GRISSON AFB IN	3	0	0	0	0
GULFPORT MS	3	0	0	0	0
HANSCOM AFB MA	2	0	0	0	0
HECTOR FIELD	2	0	0	0	0
HICKAM AFB HI	3	0	0	5.38	0
HILL AFB UT	3	21.52	0	5.38	0
HOLLOMAN AFB NM	3	0	24.21	0	10.76
HOMESTEAD AFB FL	2	0	0	0	0
HOWARD AFB PC ZONE	3	0	0	0	0
HULMAN FLD IN	2	0	0	0	0
INCIRLIK AB TU	3	0	0	0	0
JACKSONVILLE FL	2	0	0	0	0
KADENA AB OKINAWA	3	53.8	0	0	0
KANAWHA CO APT WV	2	0	0	0	0
KEESLER AFB MS	2	0	0	0	0
KELLOGG APT MI	2	0	0	0	0
KELLY AFB TX	3	43.04	8.07	0	0
KI SAWYER AFB MI	3	0	8.07	0	0
KINGSLEY FLD OR	2	0	0	0	0
KINGSTOWN RI	2	0	0	0	0
KIRTLAND AFB NM	2	32.28	8.07	0	8.07
KUNSAN AB KOREA	2	0	0	5.38	0
LAJES AB AZORES	3	13.74	0	6.44	0
LAKENHEATH RAF UK	2	10.76	0	0	0
LANGLEY AFB VA	3	10.76	0	5.38	0
LAUGHLIN AFB TX	1	0	0	0	7
LINCOLN APT NE	2	0	0	0	0
LITTLE ROCK SFB	3	10.76	0	5.38	10.76
LORING AFB ME	3	0	0	0	0
LOUISVILLE KY	2	0	0	0	0
LUKE AFB AZ	2	10.76	0	0	0
MACDILL AFB FL	2	0	0	0	0
MADISON WI	2	0	0	0	0
MALMSTROM AFB MT	3	10.76	0	5.38	0
MANSFIELD MAP OH	2	0	0	0	0
MARCH AFB CA	3	10.76	0	5.38	0
MARTINSBURG WV	2	0	0	0	0
MATHER AFB CA	3	0	0	0	0
MAXWELL AFB AL	2	0	0	0	0
MCCHORD AFB WA	3	0	0	5.38	0
MCCLELLAN AFB CA	3	10.76	0	0	21.52
MCCONNELL AFB KS	3	10.76	0	0	0
MCENTIRE ANG EASTOVER SC	2	0	0	0	0
MCGHEE TYSON APT KNOXVILLE	3	0	0	0	0
MCGUIRE AFB NJ	3	10.76	0	5.38	0
MEMPHIS APT TN	3	0	0	0	0

Figure 91. Table of Bases with Associated Vehicle Set Number and Variance Information (continued)

MERIDIAN MS	3	0	0	0	0
MIDDLETOWN PA	2	0	0	0	0
MILDENHALL RAF UK	3	10.76	0	5.38	0
MILWAUKEE WI	3	0	0	0	0
MINNEAPOLIS MN	2	0	0	0	0
MINOT AFB ND	3	0	0	5.38	0
MISAWA AB JAPAN	2	21.52	0	0	0
MITCHELL FLD WI	2	0	0	0	0
MOODY AFB GA	2	0	0	0	0
MT HOME AFB ID	3	10.76	0	5.38	0
NASHVILLE TN	3	0	0	0	0
NELLIS AFB NV	3	32.28	5.38	5.38	0
NEWBURGH NY	3	0	0	0	0
NIZGARA FALLS IAP NY	2	0	0	0	0
OFFUTT AFB NE	3	10.76	0	5.38	0
OSAN AB KOREA	3	0	0	5.38	0
OTIS ANG MA	2	0	0	0	0
PATRICK AFB FL	3	10.76	0	5.38	0
PEASE AFB NH	3	0	0	0	0
PETERSON AFB CO	3	10.76	0	5.38	0
PHEONIX AZ	2	0	0	0	0
PLATSBURGH NY	3	10.76	0	5.38	0
PLEASANTVILLE NJ	2	0	0	0	0
POPE AFB NC	2	10.76	8.07	5.38	8.07
PORTLAND IAP OR	2	0	0	0	0
RAMSTEIN AB GE	3	21.52	0	5.38	0
RANDOLPH AFB TX	1	0	0	0	7
REESE AFB TX	1	0	0	0	7
RENO MAY NV	2	0	0	0	0
RHEIN MAIN AB GE	3	0	0	5.38	0
RICKENBACKER OH	3	0	0	0	0
ROBINS AFB GA	3	21.52	0	5.38	0
SALTLAKE CITY UT	3	0	0	0	0
SAN JUAN PR	3	0	0	0	0
SCHENECTADY APT NY	2	0	0	0	0
SCOTT AFB IL	3	10.76	0	5.38	0
SELFRIDGE ANG MI	3	0	0	0	0
SEYMOUR JOHNSON NC	3	10.76	8.07	0	0
SHAW AFB SC	2	0	0	0	0
SHEMYA AFB AK	3	0	0	0	0
SHEPPARD AFB TX	1	0	0	0	7
SIOUX CITY ANG IA	2	0	0	0	0
SIOUX FALLS SD	2	0	0	0	0
SPANGDAHLEM AG GE	2	0	0	0	0
SPRINGFIELD APT OH	2	0	0	0	0
ST JOSEPH MO	2	0	0	0	0
ST PAUL IAP MN	2	0	0	0	0
SUFFLOLK CO APT	2	0	0	0	0
SYRACUSE NY	3	0	0	0	0
THOMPSON FLD MS	3	0	0	0	0
THULE AB GL	3	0	0	0	0
THURMRAIT OMEN	2	0	0	0	0
TINKER AFK OK	3	32.28	0	0	0
TOLEDO APT OH	2	0	0	0	0
TOPEKA KS	3	0	0	0	0
TORREJON AB SPAIN	2	0	0	0	0

Figure 91. Table of Bases with Associated Vehicle Set Number and Variance Information (continued)

TRAVIS AFB CA	3	10.76	8.07	0	0
TUCSON IAP AZ	2	0	0	0	0
TULSA OK	2	0	0	0	0
TYNDALL AFB FL	2	10.76	0	0	5
UPPER HEYFORD UK	2	0	0	0	0
VANCE AFB OK	1	0	0	0	0
VANDENBERG	3	64.56	0	5.38	0
W ROGERS APT OK	3	0	0	0	0
WESTOVER AFB MA	3	0	0	0	0
WHITEMAN AFB MO	3	10.76	0	5.38	0
WILLOW GROVE PA	2	0	0	0	0
WRIGHT PATTERSON AFK OH	3	53.8	0	5.38	0
YOKOTA AB JAPAN	3	21.52	0	5.38	0
YOUNGSTOWN MAP OH	3	0	0	0	0

Figure 91. Table of Bases with Associated Vehicle Set Number and Variance Information (continued)

Lookup Table #1
LIST OF BASES WITH VEH. SET # AND VARIANCES

Var. 5	Var. 6	Var. 7	Var. 8	P-15's	Base Name
0	-13.45	0	1	0	ACADEMY
0	0	0	0	0	AL JHARJ SAUDI
0	0	0	0	0	ALCONBURY RAF UK
0	0	0	0	0	ALPENA MI
0	0	0	0	1	ALTUS AFB OK
0	0	0	0	0	ANCHORAGE AK
0	0	0	0	1	ANDERSON AFB GU
0	0	8.07	1	1	ANDREWS AFB MD
0	0	0	0	0	ARNOLD AFS TN
0	0	0	0	0	AVIANO AB IT
0	0	0	0	0	BALTIMORE MD
0	0	0	0	1	BANGOR IAP ME
0	0	0	0	1	BARKSDALE AFB LA
0	0	0	0	0	BARNES APT MA
0	0	0	0	1	BEALE AFB CA
0	0	0	0	0	BERGSTROM AFB TX
0	0	0	0	0	BIRMINGHAM APT AL
0	0	0	0	0	BITBURG AB GE
0	0	0	0	0	BOISE APT ID
0	0	0	0	0	BRADLEY AND CT
0	0	0	0	0	BRIDGTOWN MO
0	0	0	0	0	BUCKLEY ANG CO
0	0	0	0	0	BURLINGTON IAP VT
0	0	0	0	0	BYRD FLD VA
0	0	0	0	0	CAMP DOUGLAS WI
0	0	0	0	0	CANNON AFB NM
0	0	0	0	0	CAPITAL APT IL
0	0	0	0	1	CARSWELL AFB TX
0	0	0	0	1	CASTLE AFB CA
0	0	0	0	1	CHARLESTON AFB SC
0	0	0	0	0	CHARLOTTE ANG NC
0	0	0	0	0	CHEYENNE MAP WY
0	0	0	0	0	CHICAGO-OHARE
0	0	0	0	0	COLORADO SPRINGS
0	0	0	0	0	COLUMBUS AFB MS
0	0	0	0	0	DANELLY ANG AL
0	0	0	0	0	DAVIS MONTHAN AZ
0	0	0	0	0	DES MOINES MAP IA
0	0	0	0	0	DIYARBAKIR AS
0	0	0	0	0	DOBBINS AFB GA
0	0	0	0	1	DOVER AFB DE
0	0	0	0	0	DULUTH MN
0	0	0	0	1	DYESS AFB TX
0	0	0	1	1	EDWARDS AFB CA
102.22	0	0	1	0	EGLIN AFB FL
0	0	0	0	1	EIELSON AFB AK
0	0	0	0	0	ELLINGTON AFB TX
0	0	0	1	1	ELLSWORTH AFB SD
0	0	0	2	1	ELMENDORF AFB AK
0	0	0	0	1	FAIRCHILD AFB WA
0	0	0	0	0	FAIRFORD RAF UK

Figure 91. Table of Bases with Associated Vehicle Set Number and Variance Information (continued)

0	0	0	0	0	FRESNO APT CA
0	0	0	0	0	FT SMITH MAP AF
0	0	0	0	0	FT WAYNE MAP IN
0	0	0	0	0	GARDEN CITY GA
0	0	0	0	1	GRAND FORKS ND
0	0	0	0	0	GREAT FALLS IAP
0	0	0	0	0	GREATER PEORIA APT IL
0	0	0	0	0	GREATER PITTSBURGH IAP PA
0	0	0	0	0	GREATER WILMINGTON APT DE
0	0	0	1	1	GRIFFIS AFB NY
0	0	0	0	1	GRISSON AFB IN
0	0	0	0	0	GULFPORT MS
0	-13.45	0	0	0	HANSCOM AFB MA
0	0	0	0	0	HECTOR FIELD
0	0	0	1	1	HICKAM AFB HI
0	0	0	0	1	HILL AFB UT
0	0	0	2	0	HOLLOMAN AFB NM
0	0	0	0	0	HOMESTEAD AFB FL
0	0	0	0	0	HOWARD AFB PC ZONE
0	0	0	0	0	HULMAN FLD IN
0	0	0	0	0	INCIRLIK AB TU
0	0	0	0	0	JACKSONVILLE FL
0	0	0	2	1	KADENA AB OKINAWA
0	0	0	0	0	KANAWHA CO APT WV
0	0	0	1	0	KEESLER AFB MS
0	0	0	0	0	KELLOGG APT MI
0	0	0	3	1	KELLY AFB TX
0	0	0	0	1	KI SAWYER AFB MI
0	0	0	0	0	KINGSLEY FLD OR
0	0	0	0	0	KINGSTOWN RI
0	0	0	1	0	KIRTLAND AFB NM
0	0	0	0	0	KUNSAN AB KOREA
0	0	0	0	1	LAJES AB AZORES
0	0	0	0	0	LAKENHEATH RAF UK
0	0	0	0	1	LANGLEY AFB VA
0	0	0	0	0	LAUGHLIN AFB TX
0	0	0	0	0	LINCOLN APT NE
0	0	0	0	1	LITTLE ROCK SFB
0	0	0	0	1	LORING AFB ME
0	0	0	0	0	LOUISVILLE KY
0	0	0	0	0	LUKE AFB AZ
0	-13.45	0	0	0	MACDILL AFB FL
0	0	0	0	0	MADISON WI
0	0	0	0	1	MALMSTROM AFB MT
0	0	0	0	0	MANSFIELD MAP OH
0	0	0	0	1	MARCH AFB CA
0	0	0	0	0	MARTINSBURG WV
0	0	0	0	1	MATHER AFB CA
29.52	0	0	1	0	MAXWELL AFB AL
0	0	0	0	1	MCCHORD AFB WA
0	0	0	2	1	MCCLELLAN AFB CA
0	0	0	0	1	MCCONNELL AFB KS
0	0	0	0	0	MCENTIRE ANG EASTOVER SC
0	0	0	0	1	MCGHEE TYSON APT KNOXVILLE TN
0	0	0	0	1	MCGUIRE AFB NJ
0	0	0	0	0	MEMPHIS APT TN

Figure 91. Table of Bases with Associated Vehicle Set Number and Variance Information (continued)

0	0	0	0	0	MERIDIAN MS
0	0	0	0	0	MIDDLETOWN PA
0	0	0	0	1	MILDENHALL RAF UK
0	0	0	0	0	MILWAUKEE WI
0	0	0	0	0	MINNEAPOLIS MN
0	0	0	0	1	MINOT AFB ND
0	0	0	0	0	MISAWA AB JAPAN
0	0	0	0	0	MITCHELL FLD WI
0	0	0	0	0	MOODY AFB GA
0	0	0	0	0	MT HOME AFB ID
0	0	0	0	0	NASHVILLE TN
0	0	0	0	1	NELLIS AFB NV
0	0	0	0	1	NEWBURGH NY
0	0	0	0	0	NIZGARA FALLS IAP NY
0	0	0	1	1	OFFUTT AFB NE
0	0	0	1	1	OSAN AB KOREA
0	0	0	0	0	OTIS ANG MA
0	0	0	0	0	PATRICK AFB FL
0	0	0	0	1	PEASE AFB NH
0	0	0	0	0	PETERSON AFB CO
0	0	0	0	0	PHEONIX AZ
0	0	0	0	1	PLATSBURGH NY
0	0	0	0	0	PLEASANTVILLE NJ
0	0	0	0	0	POPE AFB NC
0	0	0	0	0	PORTLAND IAP OR
75.83	0	0	2	1	RAMSTEIN AB GE
0	0	0	0	0	RANDOLPH AFB TX
0	0	0	0	0	REESE AFB TX
0	0	0	0	0	RENO MAY NV
0	0	0	0	1	RHEIN MAIN AB GE
0	0	0	0	0	RICKENBACKER OH
0	0	0	2	1	ROBINS AFB GA
0	0	0	0	0	SALTLAKE CITY UT
0	0	0	0	0	SAN JUAN PR
0	0	0	0	0	SCHENECTADY APT NY
0	0	0	0	0	SCOTT AFB IL
0	0	0	0	0	SELFRIDGE ANG MI
0	0	0	0	1	SEYMOUR JOHNSON NC
2.69	0	0	0	0	SHAW AFB SC
0	0	0	0	0	SHEMYA AFB AK
0	0	0	1	0	SHEPPARD AFB TX
0	0	0	0	0	SIOUX CITY ANG IA
0	0	0	0	0	SIOUX FALLS SD
0	0	0	0	0	SPANGDAHLEM AG GE
0	0	0	0	0	SPRINGFIELD APT OH
0	0	0	0	0	ST JOSEPH MO
0	0	0	0	0	ST PAUL IAP MN
0	0	0	0	0	SUFFLOLK CO APT
0	0	0	0	0	SYRACUSE NY
0	0	0	0	1	THOMPSON FLD MS
0	0	0	0	0	THULE AB GL
0	0	0	0	0	THURMRAIT OMEN
0	0	0	3	1	TINKER AFK OK
0	0	0	0	0	TOLEDO APT OH
0	0	0	0	1	TOPEKA KS
0	0	0	0	1	TORREJON AB SPAIN

Figure 91. Table of Bases with Associated Vehicle Set Number and Variance Information (continued)

0	0	0	1	1	TRAVIS AFB CA
0	0	0	0	0	TUCSON IAP AZ
0	0	0	0	0	TULSA OK
0	0	0	0	0	TYNDALL AFB FL
0	0	0	0	1	UPPER HEYFORD UK
0	0	0	0	0	VANCE AFB OK
0	0	0	1	0	VANDENBERG
0	0	0	0	0	W ROGERS APT OK
0	0	0	0	1	WESTOVER AFB MA
0	0	0	0	1	WHITEMAN AFB MO
0	0	0	0	0	WILLOW GROVE PA
0	0	0	3	1	WRIGHT PATTERSON AFK OH
0	0	0	1	1	YOKOTA AB JAPAN
0	0	0	0	0	YOUNGSTOWN MAP OH

Figure 91. Table of Bases with Associated Vehicle Set Number and Variance Information (concluded)

Lookup Table No. 2 Vehicle Allocations			
Vehicle Type	ARFF Set 1	2	3
Crash FF :			
P-2/P-23	0	1	4
P-4/P-19	3	2	0
P-13/P-20	2	2	2
Rescue :			
P-10	1	1	1
Tanker :			
P-18/P-26	1	1	1
Command :			
P/U	1	1	1
C/A 4x4	2	2	2
Step Van	1	1	1

Figure 92. Vehicle Allocation Table

Lookup Table No. 3

STANDARD MANPOWER TABLE

Total Crew Size	E-9	E-8	E-7	E-6	E-5	E-4	E-3
39	0	1	2	4	12	11	9
40	0	1	2	4	12	11	10
41	0	1	2	4	12	12	10
42	0	1	2	4	12	12	11
43	0	1	2	4	12	13	11
44	1	1	2	4	12	13	11
45	1	1	2	4	13	13	11
46	1	1	2	4	13	14	11
47	1	1	2	4	14	14	11
48	1	1	2	4	14	14	12
49	1	1	2	4	14	15	12
50	1	1	2	4	14	15	13
51	1	1	2	4	14	15	14
52	1	1	2	4	14	16	14
53	1	1	2	4	14	16	15
54	1	1	2	4	14	17	15
55	1	1	2	5	14	17	15
56	1	1	2	5	15	17	15
57	1	1	2	6	15	17	15
58	1	1	2	6	15	17	16
59	1	1	2	6	15	17	17
60	1	1	2	6	15	18	17
61	1	1	2	6	15	18	18
62	1	1	2	6	15	19	18
63	1	1	2	7	15	19	18
64	1	1	3	7	15	19	18
65	1	1	3	7	15	19	19
66	1	1	3	7	15	19	20
67	1	1	3	7	15	20	20
68	1	1	3	7	15	20	21
69	1	1	3	7	15	20	22
70	1	1	3	8	15	20	22
71	1	1	3	8	15	21	22
72	1	1	3	8	15	21	23
73	1	1	3	8	15	22	23
74	1	1	3	8	15	22	24
75	1	1	3	8	15	22	25
76	1	1	3	8	15	23	25
77	1	1	3	8	15	23	26
78	1	1	3	8	15	23	27
79	1	1	3	8	16	23	27
80	1	1	3	8	16	24	27
81	1	1	3	8	16	24	28
82	1	1	3	9	16	24	28
83	1	1	3	9	16	25	28
84	1	1	3	9	16	25	29
85	1	1	3	9	16	25	30
86	1	1	3	9	16	26	30
87	1	1	3	9	17	26	30

Figure 93. Standard Manpower Table

88	1	1	3	9	17	26	31
89	1	1	3	10	17	26	31
90	1	1	3	10	17	27	31
91	1	1	3	10	17	27	32
92	1	1	3	10	17	27	33
93	1	1	3	10	17	28	33
94	1	1	3	10	17	28	34
95	1	1	3	10	17	29	34
96	1	1	3	10	17	29	35
97	1	1	3	10	17	29	36
98	1	1	3	10	17	29	37
99	1	1	3	10	17	30	37
100	1	1	3	10	17	30	38
101	1	1	3	10	17	31	38
102	1	1	3	10	18	31	38
103	1	1	3	11	18	31	38
104	1	1	3	11	18	32	38
105	1	1	3	11	18	32	39
106	1	1	3	11	18	33	39
107	1	1	3	11	18	33	40
108	1	1	3	11	18	34	40
109	1	1	3	11	18	35	40
110	1	1	3	11	18	35	41

Figure 93. Standard Manpower Table (concluded)

Cost Table No. 1

Vehicle Replacement And Overhaul Costs Lookup Table
(Individual and weighted group average values)

Annual Interest Rate (%) : 6.00

Vehicle Type	# In System	Replcmnt Value ($)	Expected Lifetime (yrs)	Overhaul Costs ($)	Lifetime Addition (yrs)	Annual Costs ($)
P-2	265	535,155	12	149147		
P-23	0	547,490	12			
Combined Avg.		535,155	12			63,832
P-4	310	208,556	12	134159		
P-19	431	211,566	12	107328		
Combined Avg.		210,307	12			25,085
P-15	63	822,726	12			98,132
P-13	172	42,470	10			
P-20	301	54,444	10			
Combined Avg.		50,090	10			6,806
P-10	302	40,680	11			5,158
P-18	205	148,642	12			17,730
P-27	2	70,883	8			11,415
P-8	221	149,631	16	69972		
P-22	39	153,553	15			
Combined Avg.		150,219	16			14,950
P-12	229	118,601	15	67329		
P-24	56	177,088	16			
Combined Avg.		130,093	15			13,286
P-21	13	377,648	15			38,884

REV. 3/29/93

Figure 94. Vehicle Replacement and Overhaul Costs Table

Cost Table No. 2

Manpower Cost Factors Lookup Tables

Enlisted Personnel
Standard Composite Rates

Mil Enl Grade	Basic Pay	Retiremen Funding	BAQ VHA	Misc. Pay	PCS	Standard Composite Rate
E-9	35,244	14,873	5,084	7,545	1,499	64,245
E-8	28,989	12,233	4,912	6,878	1,499	54,511
E-7	24,593	10,378	4,173	6,459	1,499	47,102
E-6	20,886	8,814	3,540	6,030	1,499	40,769
E-5	17,401	7,343	3,159	6,156	1,499	35,558
E-4	14,184	5,986	2,143	5,448	1,499	29,260
E-3	11,606	4,898	1,688	4,985	1,499	24,676

Civilian Personnel
Accelerated Annual Pay

GS Grade	Base Pay Rate	Premium Pay	Retirement @20.6%	FLSA	Accel. Annual Pay
4	20,008	5,002	5,152	3,309	33,471
5	22,560	5,640	5,809	3,731	37,740
6	25,621	6,405	6,597	4,237	42,860
7	27,569	6,892	7,099	4,559	46,119
8	31,252	7,813	8,047	6,015	53,127
9	33,086	8,272	8,520	6,368	56,245
10	37,711	9,428	9,711	7,258	64,107
11	40,336	10,084	10,387	7,763	68,569
12	49,080	12,270	12,638	9,446	83,434

Figure 95. Manpower Cost Factors Table

United States Air Force
Fire Department Cost Model

Cost Analysis Summary

Part I: Assigned Vehicle Data

Base Name : MACDILL AFB FL
ARFF Set: 2

Vehicle Type	# Assigned	Total # Positions Assn.
ARFF		
P-2/P-23	2	6
P-4/P-19	2	6
P-15	-	-
P-13/P-20	2	4
P-10	1	3
P-18/P-26	1	1
Structural		
P-27	-	-
P-8/P-22	-	-
P-12/24	1	4
P-21	-	-
Total # Positions		24

Figure 96. Cost Analysis Summary Worksheet

Cost Analysis Summary Pg. 2 of 4

Part II: Assigned Manpower Data

Base Name : MACDILL AFB FL

Position Manpower Factor 2.69

		# Personnel Assigned
Fire Operations:	Firefighters	65
	Communications	5
	Investigators/Insp.	2
Management/Administration		6
Total # Personnel Assigned		78

Grade Distribution (From user input)

	Fire Operations		Mgmt./Admin.		
Enlisted Grade	# Assn.	GS Grade	# Assn.	GS Grade	Subtotal By E Grade
E-9	-		1	12	1
E-8	-		1	11	1
E-7	-		3	10	3
E-6	4	8	4	9	8
E-5	15	7	-		15
E-4	23	6	-		23
E-3	27	5	-		27
Totals	69		9		78

Figure 96. Cost Analysis Summary Worksheet (continued)

Cost Analysis Summary Pg. 3 of 4

Part III: Vehicle Cost Data

Base Name : MACDILL AFB FL

Interest Rate (Annual %): 6.00

Vehicle Type	# Assigned (By User)	Amortized Replacement Cost/Unit	Tot. Annual Costs per Veh. Type
ARFF			
P-2/P-2	2	63,832	127,663
P-4/P-19	2	25,085	50,170
P-15	-	-	0
P-13/P-20	2	6,806	13,611
P-10	1	5,158	5,158
P-18	1	17,730	17,730
ARFF Subtotal			214,332
Structural			
P-27	-	-	0
P-8/P-22	-	-	0
P-12/24	1	13,286	13,286
P-21	-	-	0
Structural Subtotal			13,286
Total Annual Vehicle Costs			227,618

Figure 96. Cost Analysis Summary Worksheet (continued)

Cost Analysis Summary Pg. 4 of 4

Part IV: Manpower Cost Data

Base Name : MACDILL AFB FL

Military/Civilian Combination Ratios (Total=1.0)

Military	0.6
Civilian	0.4

Enlisted Grade	Fire Operations # Assn.	Fire Operations Avg. Cost	Mgmt./Admin. # Assn.	Mgmt./Admin. Avg. Cost	Cost By E Grade
E-9	-	-	1	71,920	71,920
E-8	-	-	1	60,134	60,134
E-7	-	-	3	53,904	161,712
E-6	4	45,712	4	46,959	370,686
E-5	15	39,782	-	-	596,737
E-4	23	34,700	-	-	798,104
E-3	27	29,902	-	-	807,341
Subtotal					2,866,635

Total Manpower Cost 2,866,635

Total Department Cost	3,094,253

Figure 96. Cost Analysis Summary Worksheet (concluded)

grade distribution of them). Page 3 lists the annual vehicle cost per vehicle type based on an interest rate which the user may assign. The final page (Page 4) totals the manpower cost and displays the combined annual vehicle and manpower cost at the bottom.

C. CONCLUSIONS

This model is an effective tool for estimating the operating the annual fire department operating cost of a base. The model allows the user to view the authorized vehicles and manpower for a particular base and then choose their own values. As a result, the impact of manpower and vehicle changes can be determined quickly.

SECTION VI
CONCLUSION

This study showed no significant difference between the overall performance of USAF and civilian fire departments. As a result, one can expect the trends observed with one database to generally agree with the other database. This result is important since the civilian database is far more complete than that for the USAF.

Using both databases, an increase in dollar losses was observed as the response time increased. Flame and smoke damage increased sharply during the first four minutes. There was not enough information about casualties to determine if there was any relationship with response time.

These results suggest that the financial gain associated with closing bases and reducing manpower should be carefully weighed against the higher losses which may result. The cost model which was developed can provide a means of quantifying monetary changes by allowing the user to vary his/her manning and vehicle assignments.

REFERENCES

1. National Fire Protection Association, "NFPA 901, Uniform Coding for Fire Protection," 1986 edition in National Fire Codes, National Fire Protection Association, Quincy, MA, 1989.

2. Department of Defense, "DoD 6055.7-M, Fire Incident Reporting," Department of Defense, February 1984.

3. National Fire Protection Association, "NFPA 101, Life Safety Code," 5th Edition in National Codes, National Fire Protection Association, Quincy, MA, 1991.

4. Department of Defense, "DoD 6055.6, Department of Defense Fire Protection Program," Department of Defense, June 1981.

5. Air Force Manning Standard 4426, Tyndall Air Force Base.

6. Proposed changes for Table of Allowances, Aircraft Rescue and Firefighting Vehicle Sets, 1993.

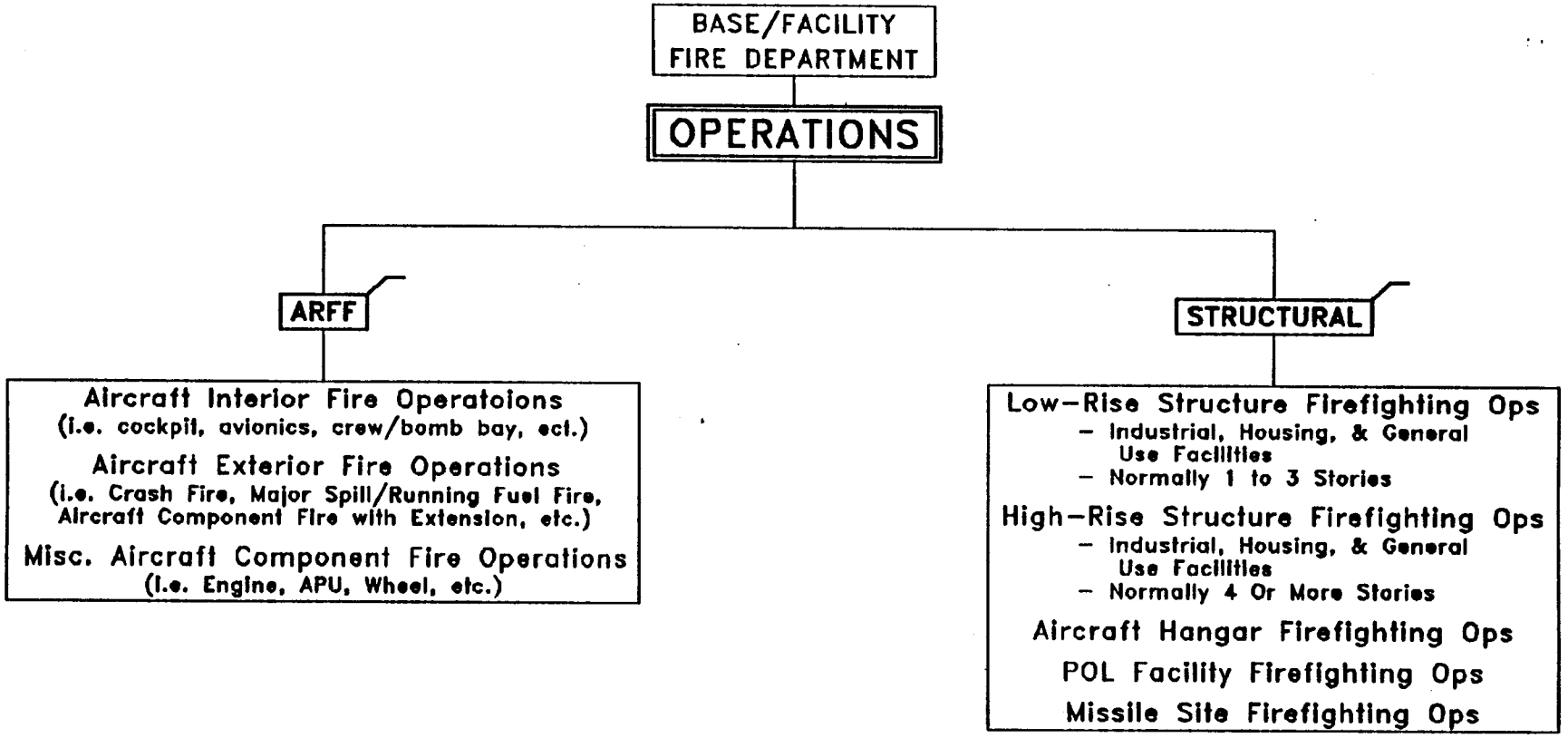
7. Air Force Regulation 173-13, September, 1992.

APPENDIX A
WORK BREAKDOWN STRUCTURE ANALYSIS

This appendix consists of a series of flow charts which detail the work breakdown structure for both aircraft (ARFF) and structural fire scenarios. Each scenario begins with the initial alarm/dispatch step and continues through the final salvage/overhaul step. These flow charts are organized in levels which are labelled in the lower right hand corner. A large, more detailed chart is included for the Aircraft Interior Fire Scenario. It lists the roles of Communications, Fire Chief (SFO), Assistant Chief of Operations (OSC), Firefighting Crews and Vehicles, Rescue Crews and Vehicles, and Tanker/Support Vehicles in a more straightforward format.
(Note: The large detailed chart is not included in this report. Contact the Office of the Air Force Fire Marshal if a copy is desired.)

USAF BASE/FACILITY FIRE DEPARTMENT

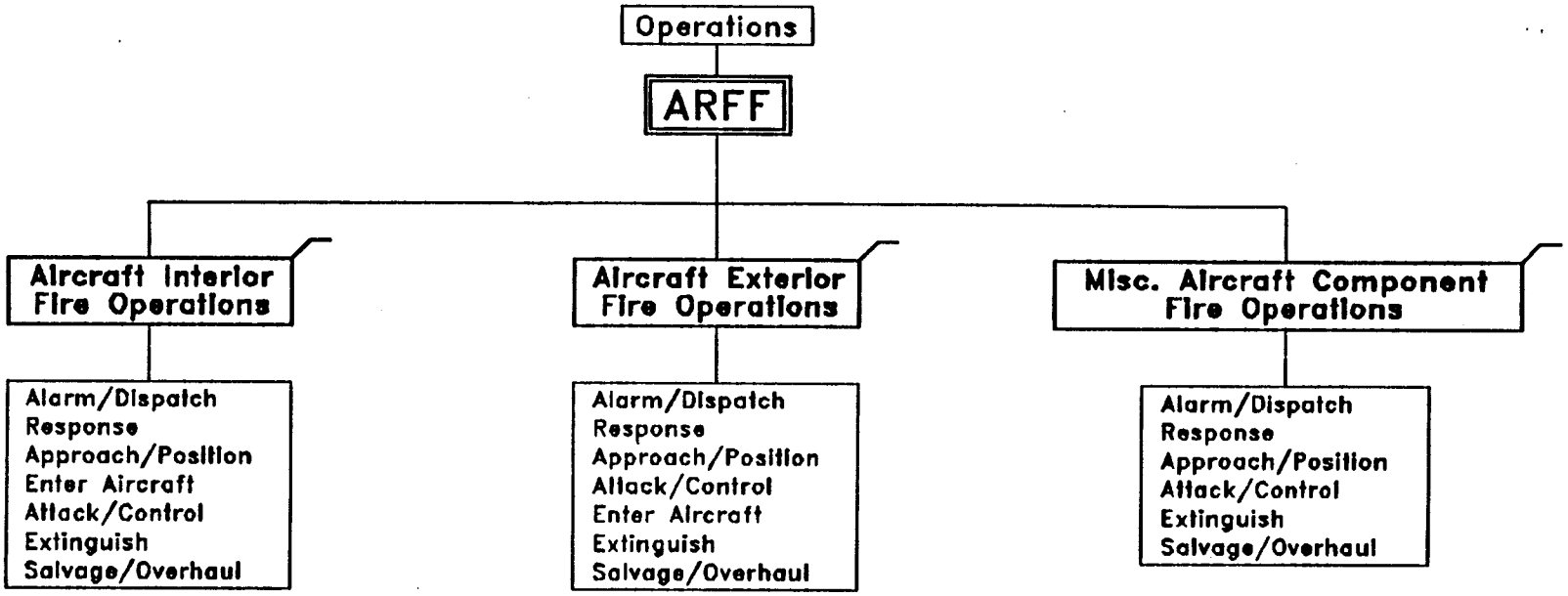
Task Oriented WBS



Operational Types
Level 01
Page 02 of 00

USAF BASE/FACILITY FIRE DEPARTMENT

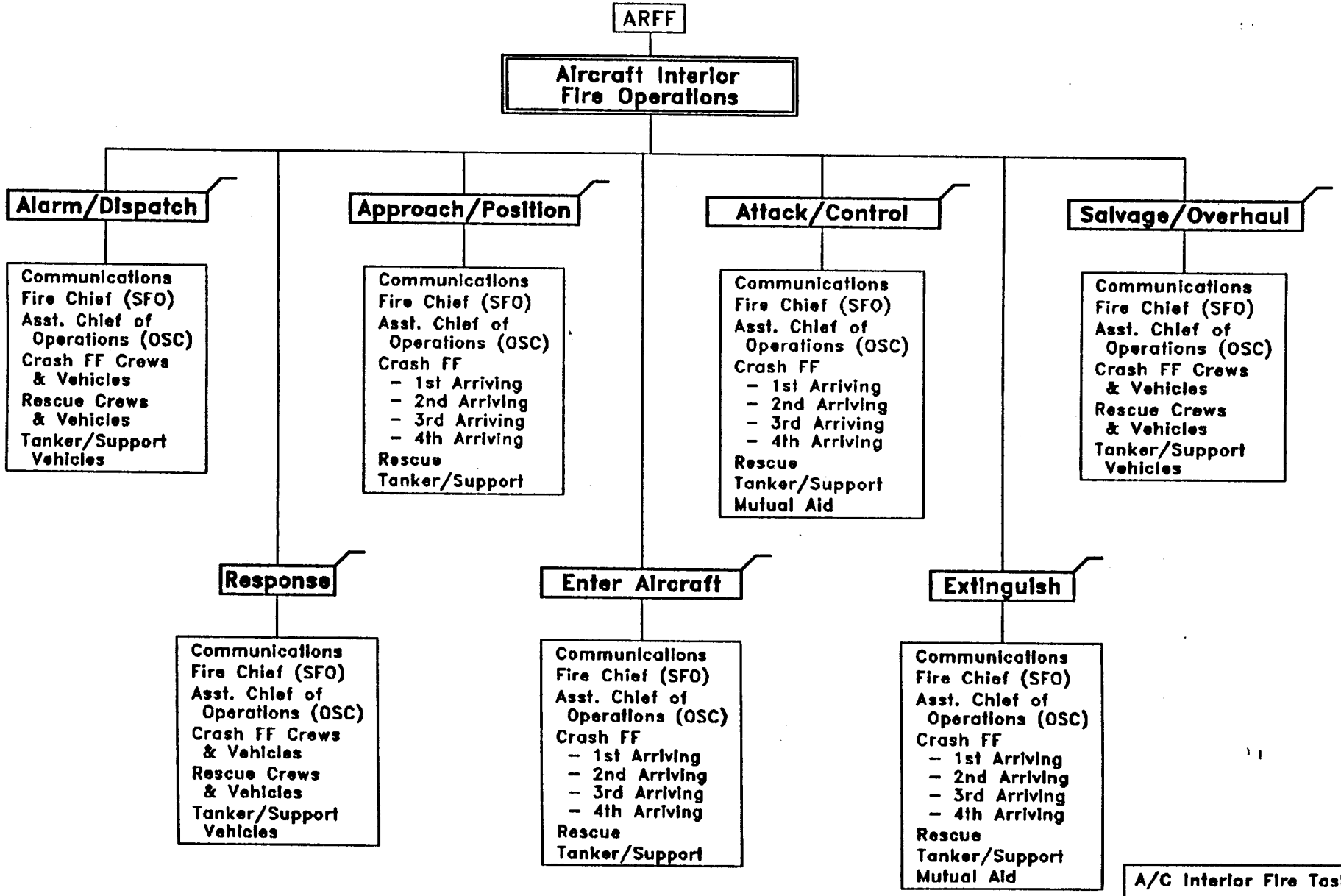
Task Oriented WBS



ARFF Incidents
Level 02
Page 03 of 00

USAF BASE/FACILITY FIRE DEPARTMENT

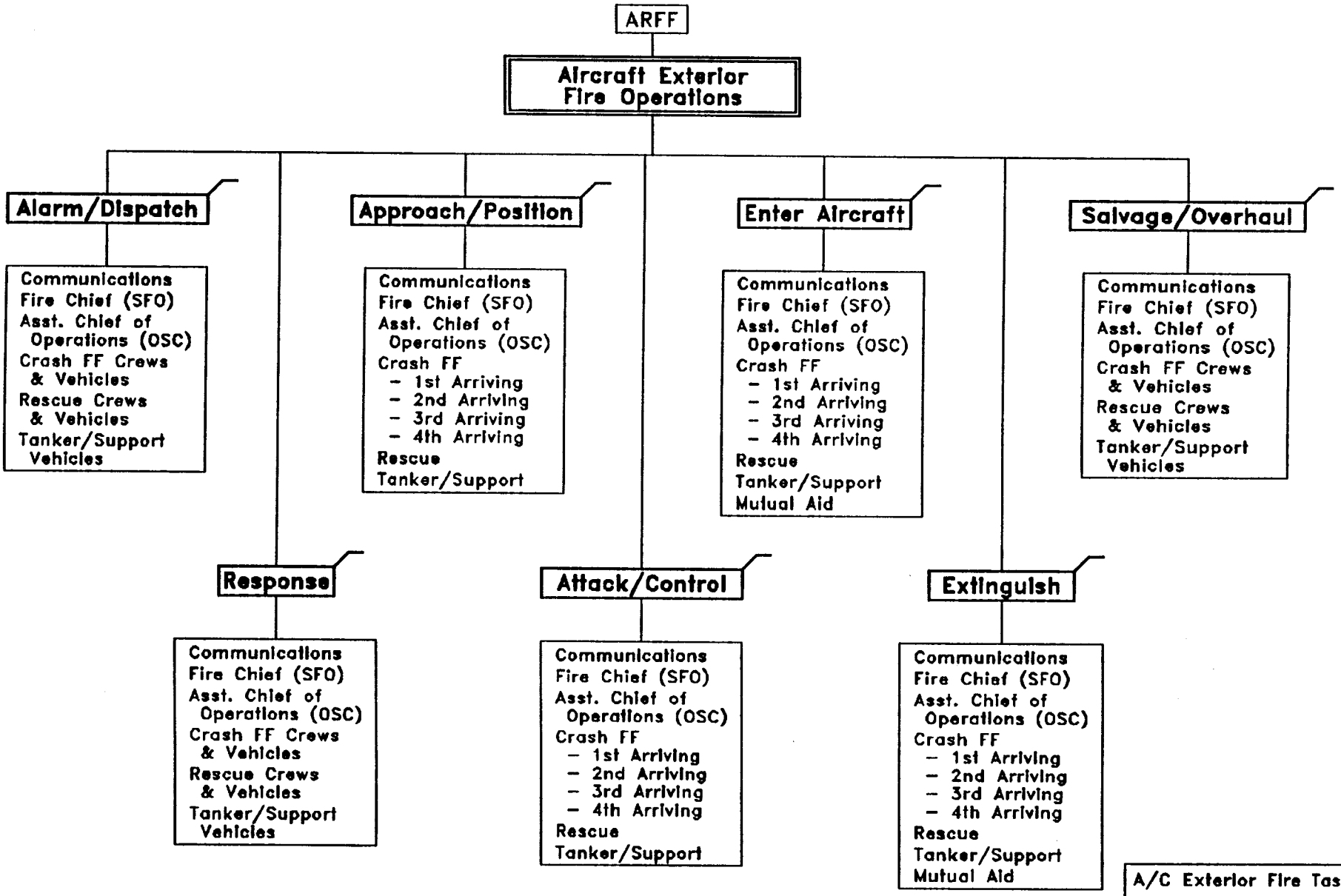
Task Oriented WBS



A/C Interior Fire Tasks
Level 03
Page 04 of 00

USAF BASE/FACILITY FIRE DEPARTMENT

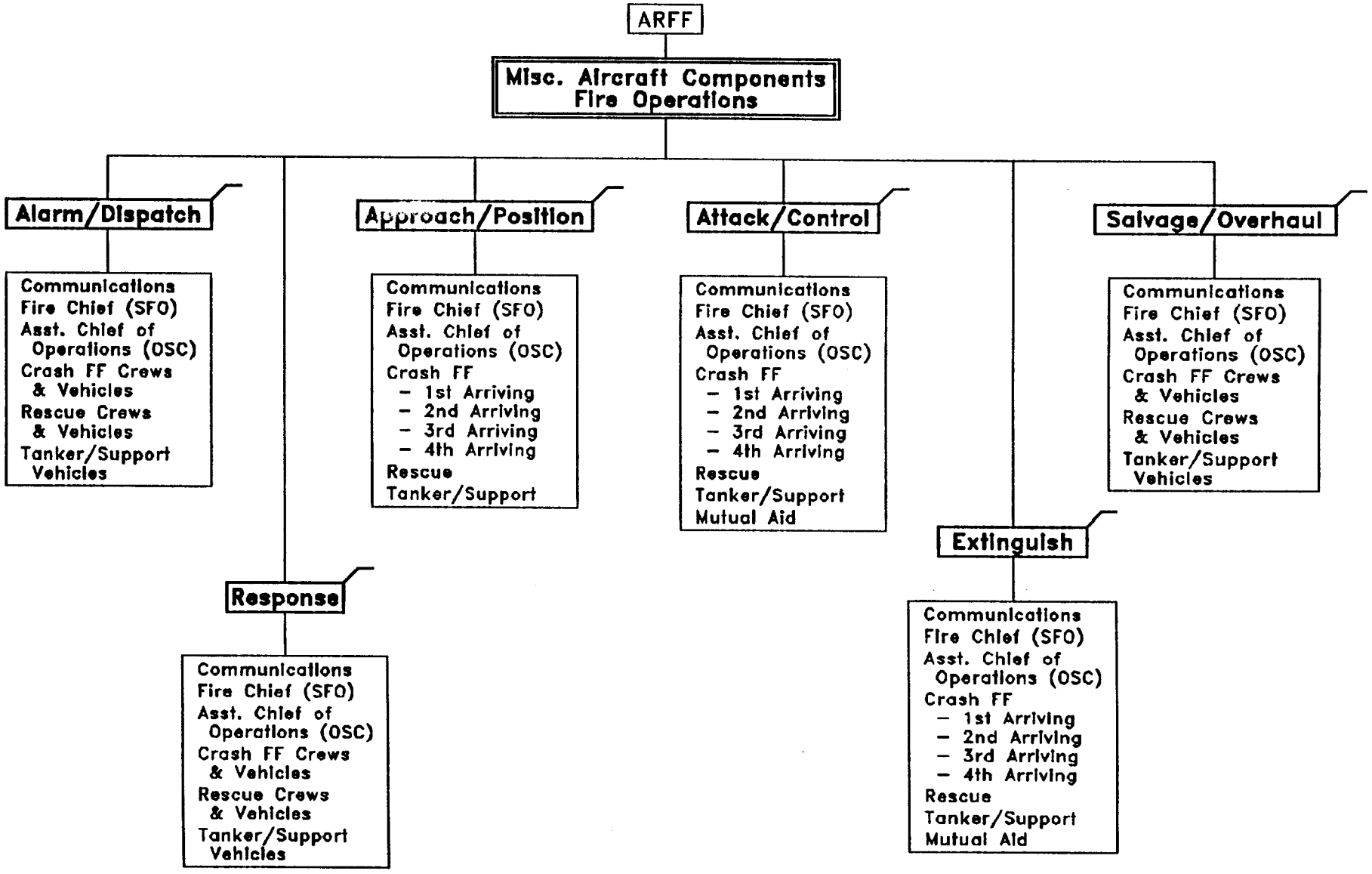
Task Oriented WBS



A/C Exterior Fire Tasks
Level 03
Page 05 of 00

USAF BASE/FACILITY FIRE DEPARTMENT

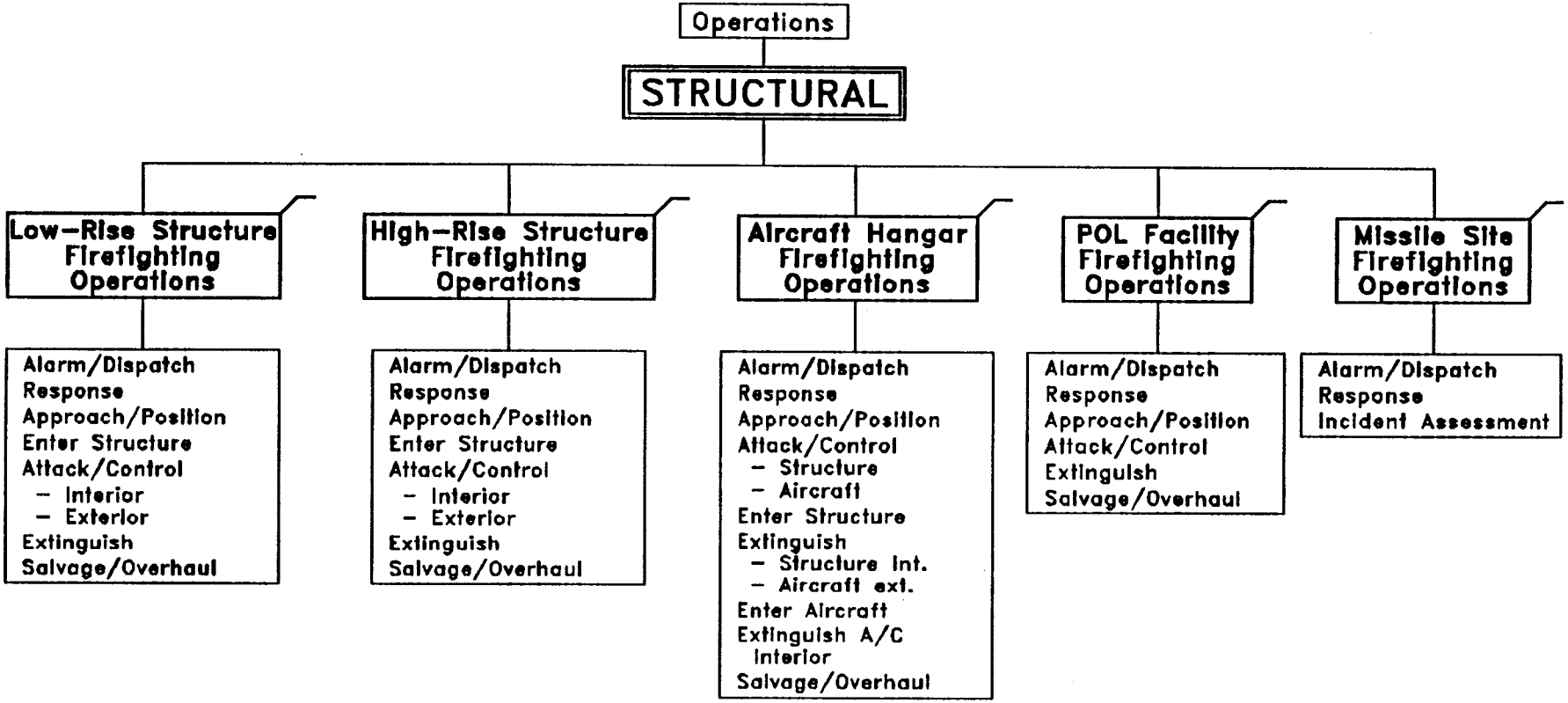
Task Oriented WBS



Misc. A/C Component Fire Tasks
Level 03
Page 06 of 00

USAF BASE/FACILITY FIRE DEPARTMENT

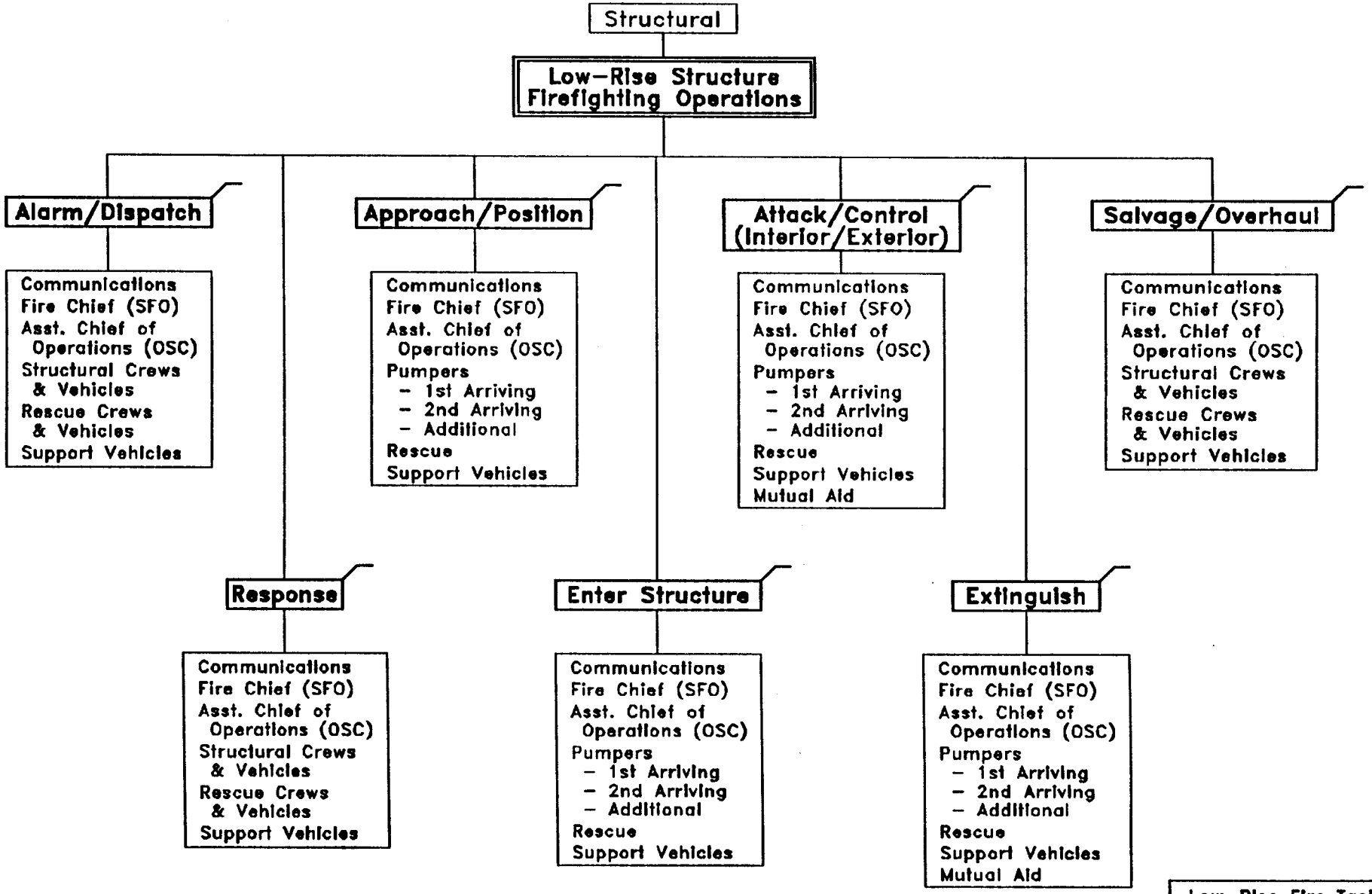
Task Oriented WBS



Structural Incidents
Level 02
Page 07 of 00

USAF BASE/FACILITY FIRE DEPARTMENT

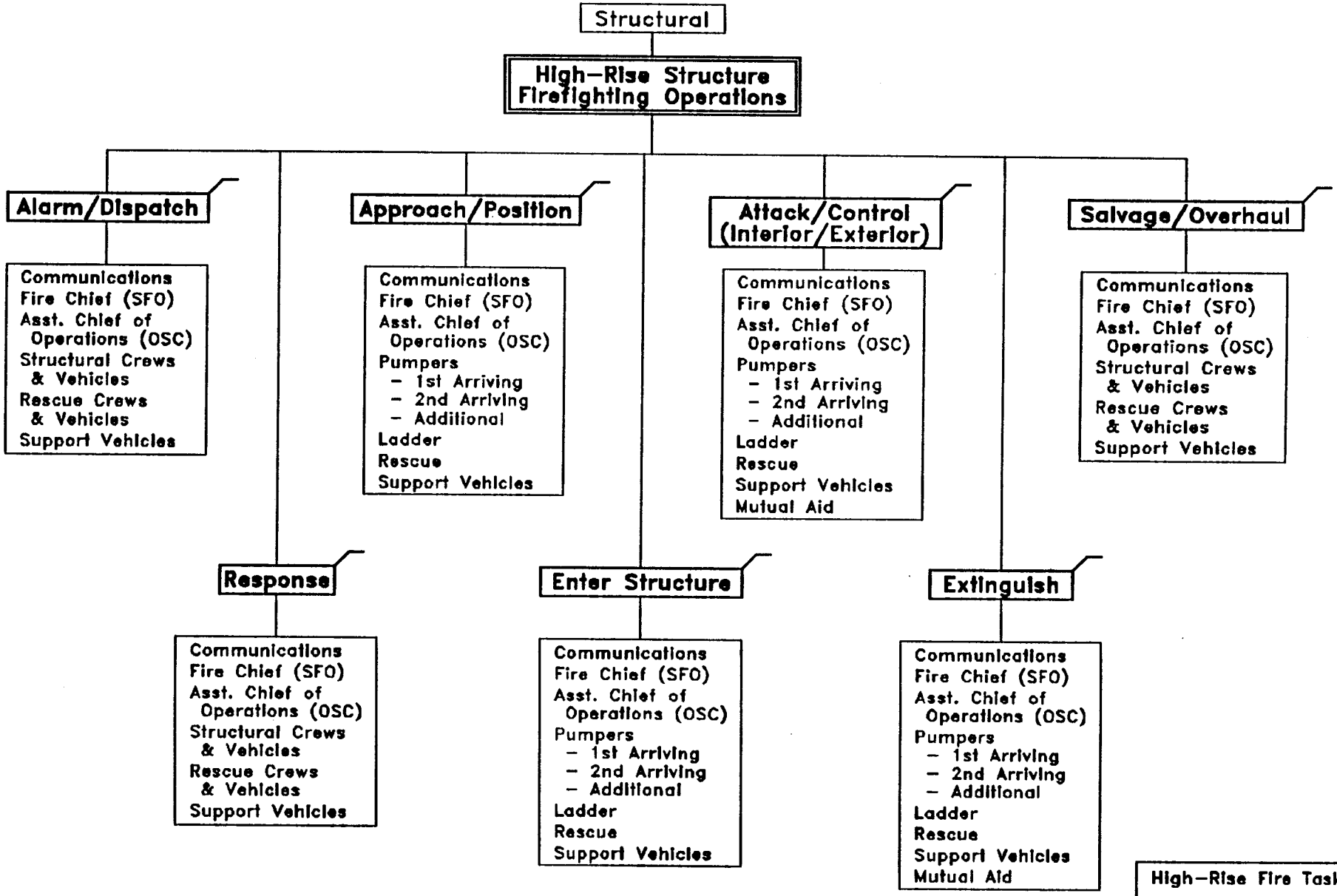
Task Oriented WBS



Low-Rise Fire Tasks
Level 03
Page 08 of 00

USAF BASE/FACILITY FIRE DEPARTMENT

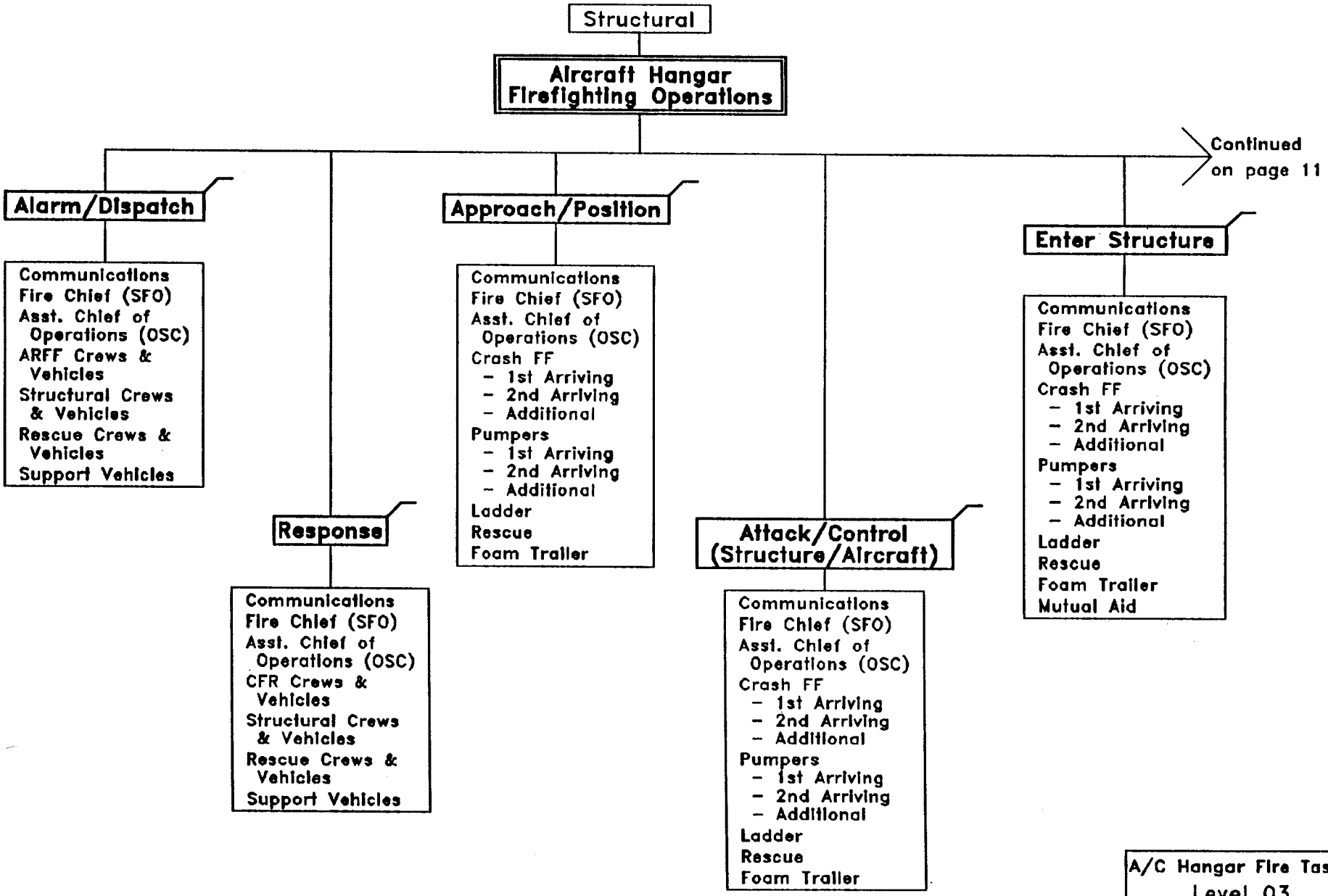
Task Oriented WBS



High–Rise Fire Tasks
Level 03
Page 09 of 00

USAF BASE/FACILITY FIRE DEPARTMENT

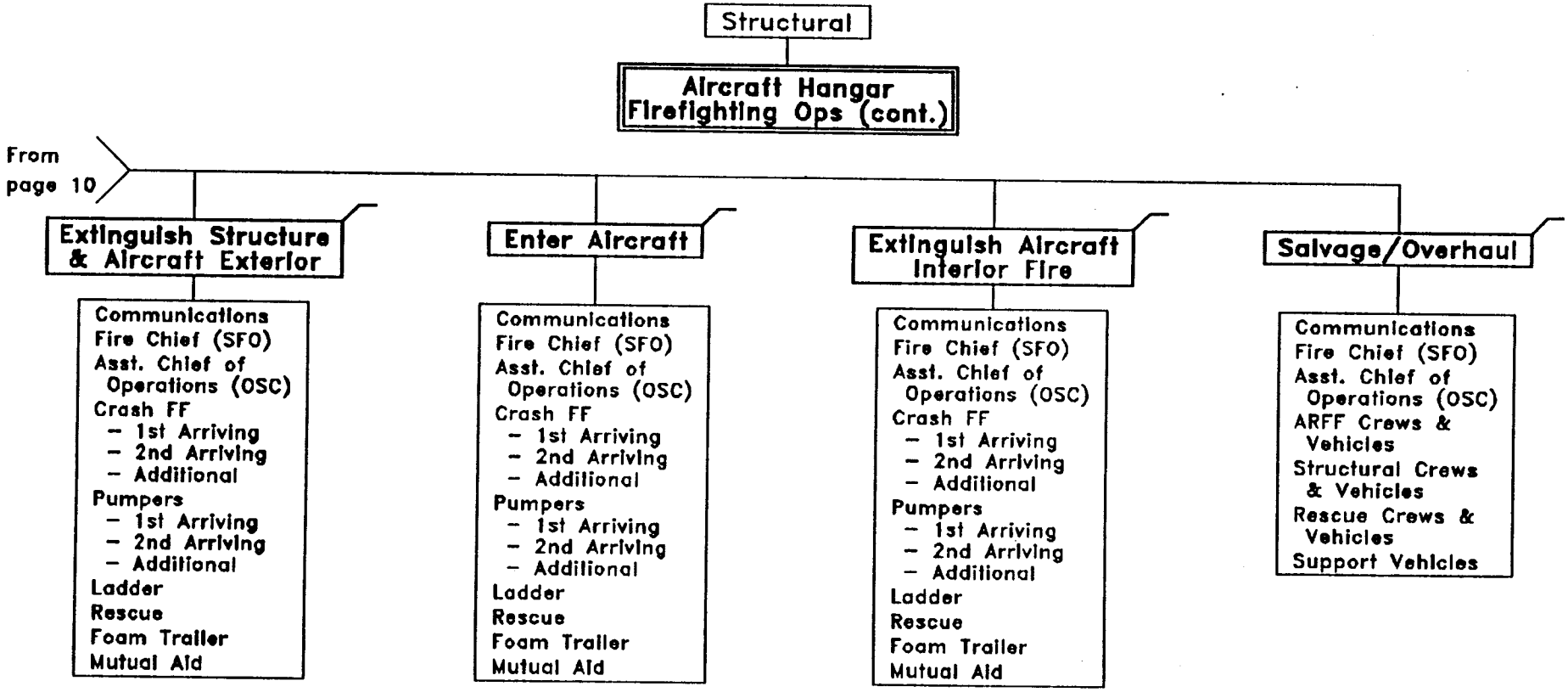
Task Oriented WBS



A/C Hangar Fire Tasks
Level 03
Page 10 of 00

USAF BASE/FACILITY FIRE DEPARTMENT

Task Oriented WBS



A/C Hangar Fire Tasks
Level 03
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USAF BASE/FACILITY FIRE DEPARTMENT

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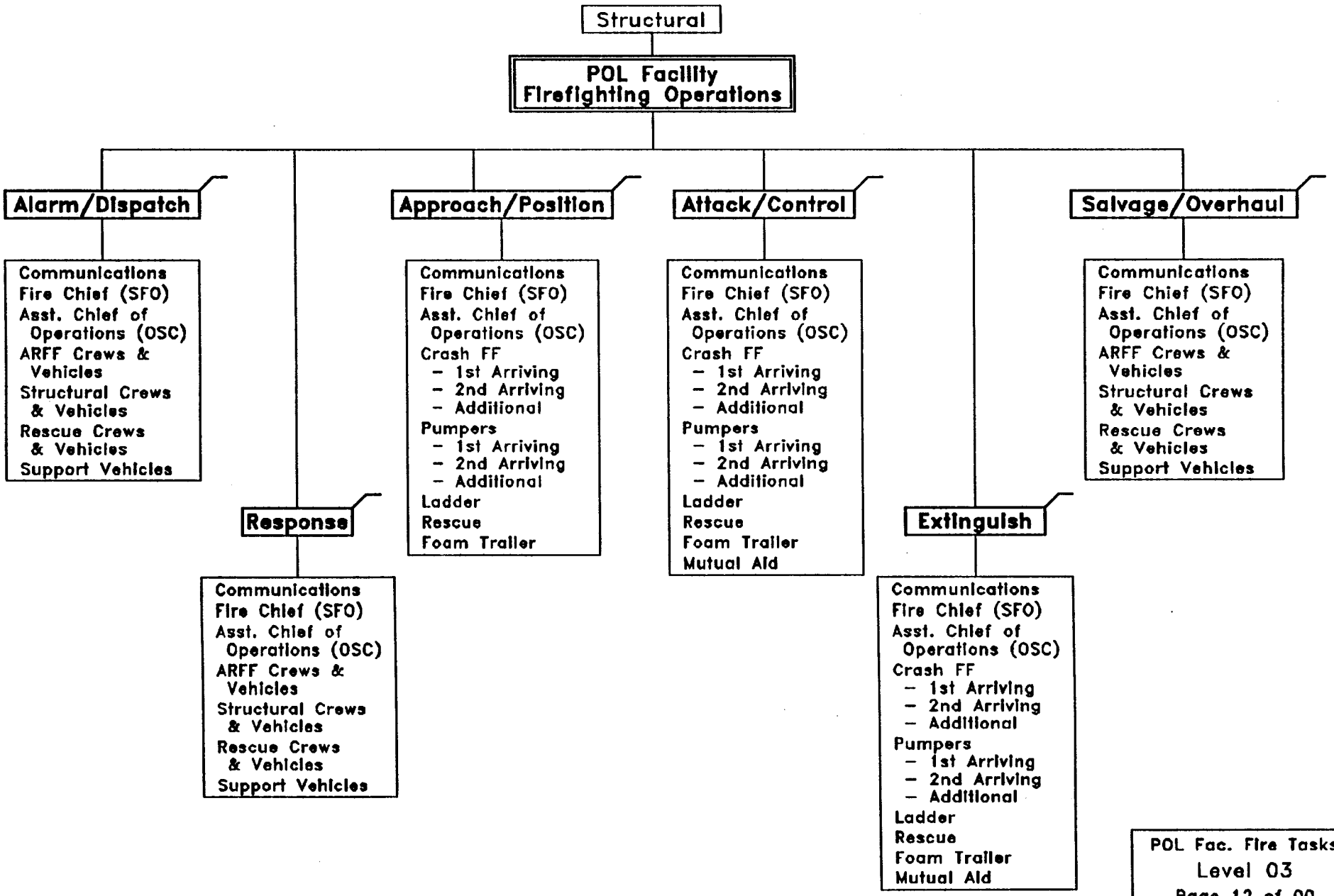
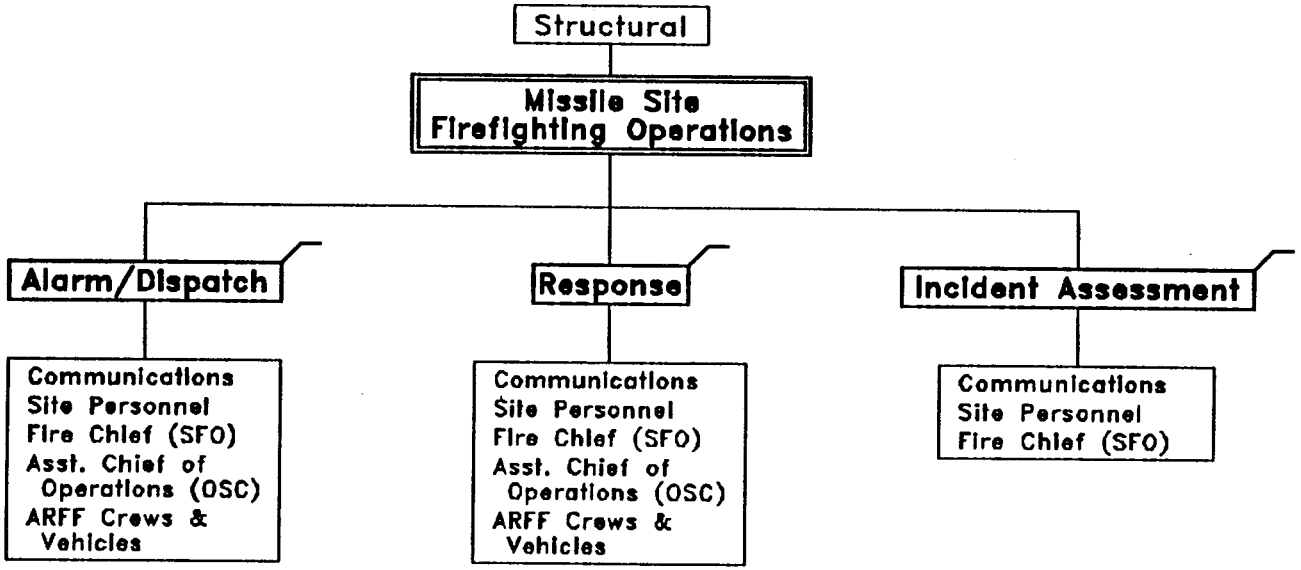


POL Fac. Fire Tasks
Level 03
Page 12 of 00

USAF BASE/FACILITY FIRE DEPARTMENT

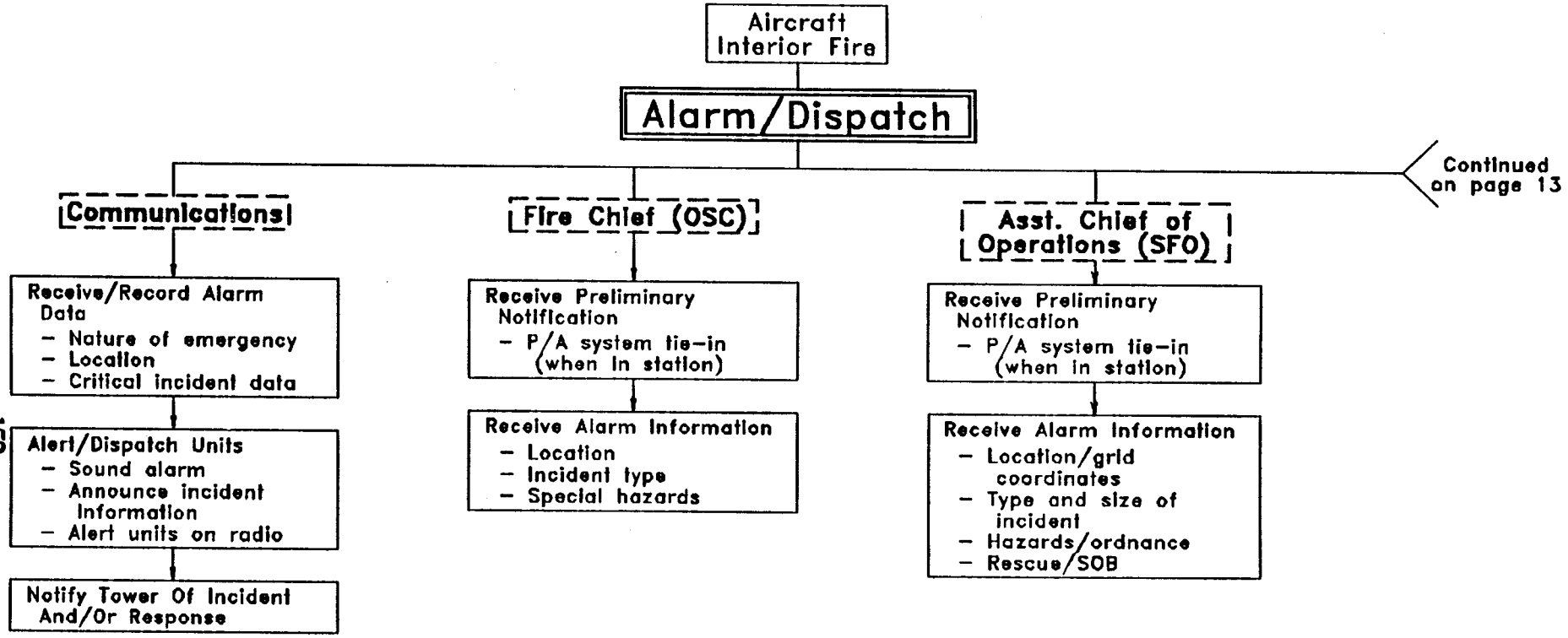
Task Oriented WBS



Miss. Site Fire Tasks
Level 03
Page 13 of 00

USAF INSTALLATION FIRE DEPARTMENT

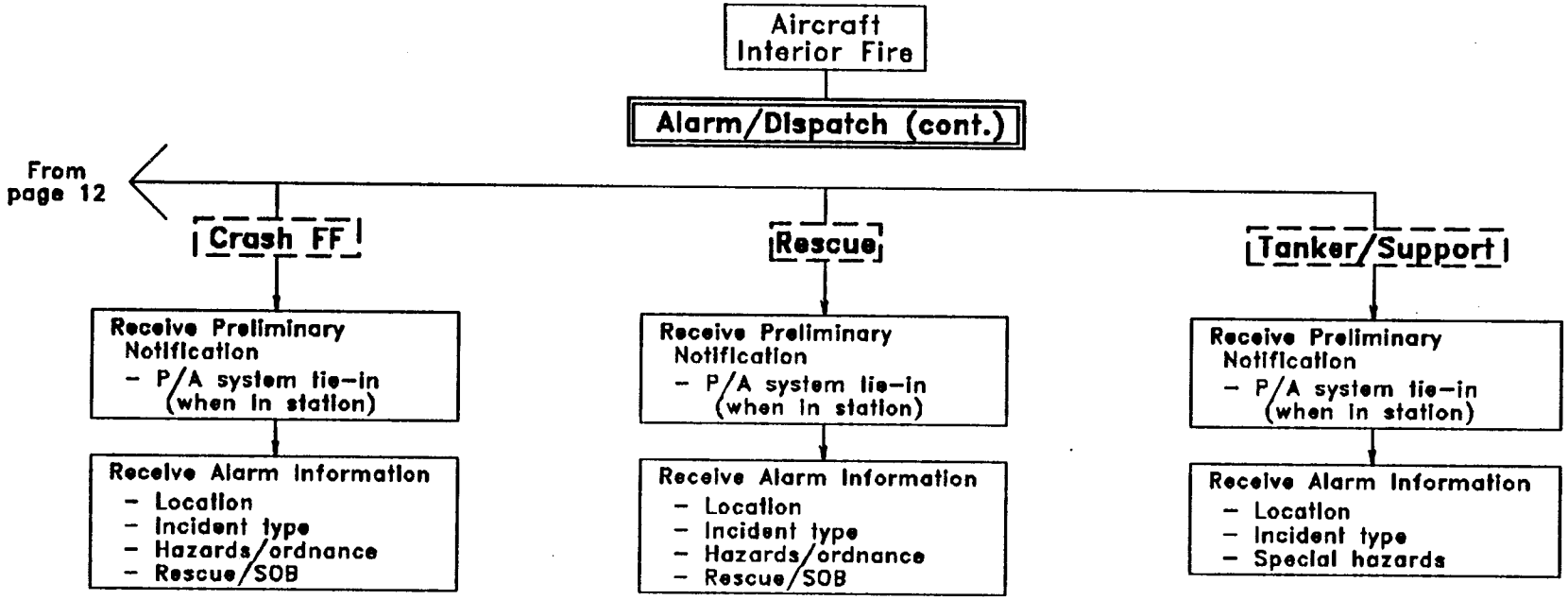
Task Oriented WBS



Alarm/Dispatch Tasks
(A/C Interior Fire)
Level 04
Page 12 of 00

USAF INSTALLATION FIRE DEPARTMENT

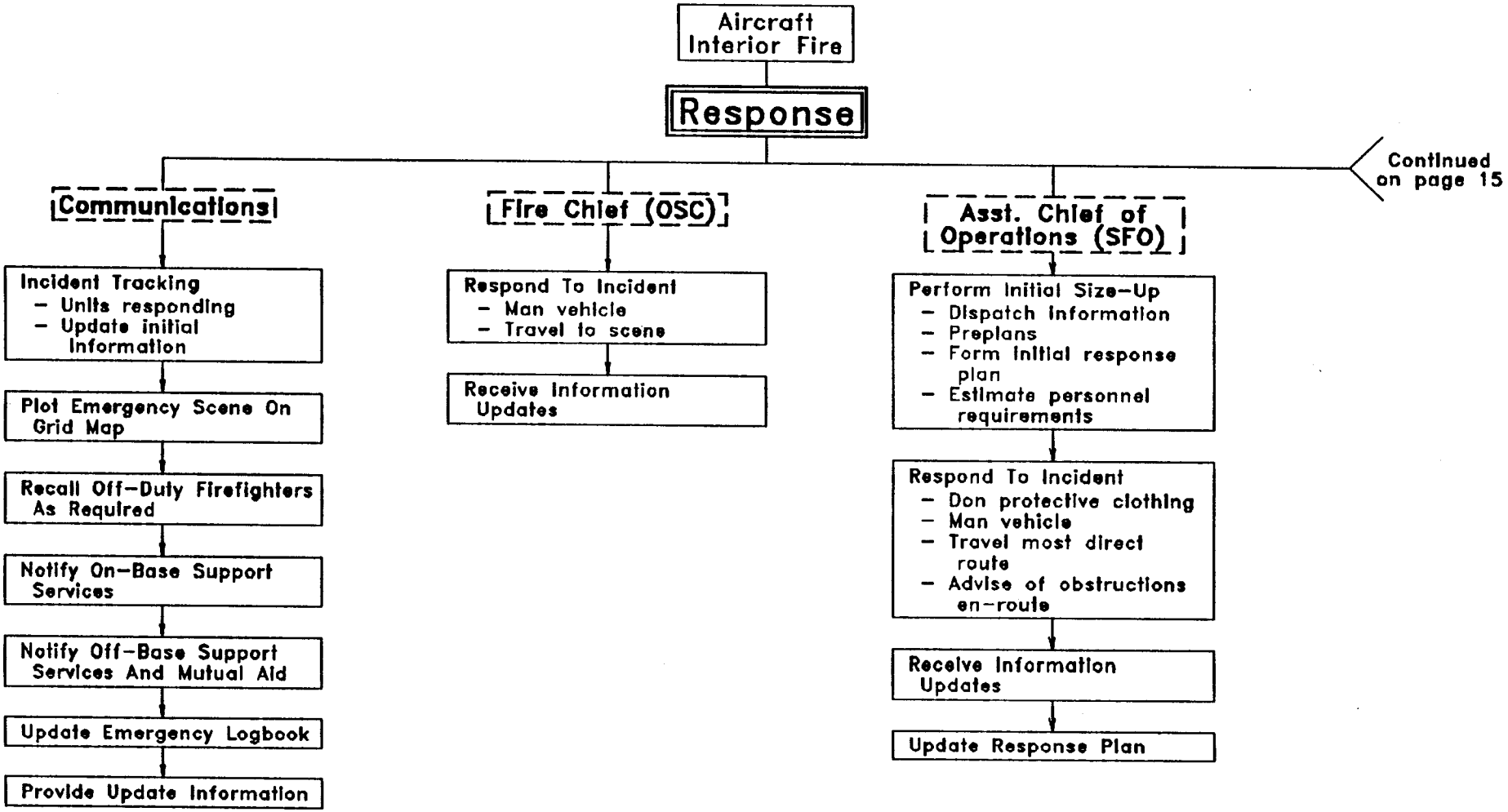
Task Oriented WBS



Alarm/Dispatch Tasks (A/C Interior Fire)
Level 04
Page 13 of 00

USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Response Tasks
(A/C Interior Fire)
Level 04
Page 14 of 00

USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS

Aircraft Interior Fire

Approach/Position

Continued on page 17

Communications

- Incident Tracking
  - Units arriving on scene
  - Additional services enroute
  - Update logbook
- Establish Communications Links
- Dispatch Additional Support Services As Requested

Fire Chief (OSC)

- Establish Cordon
- Establish/Refine ECP
- Update SFO

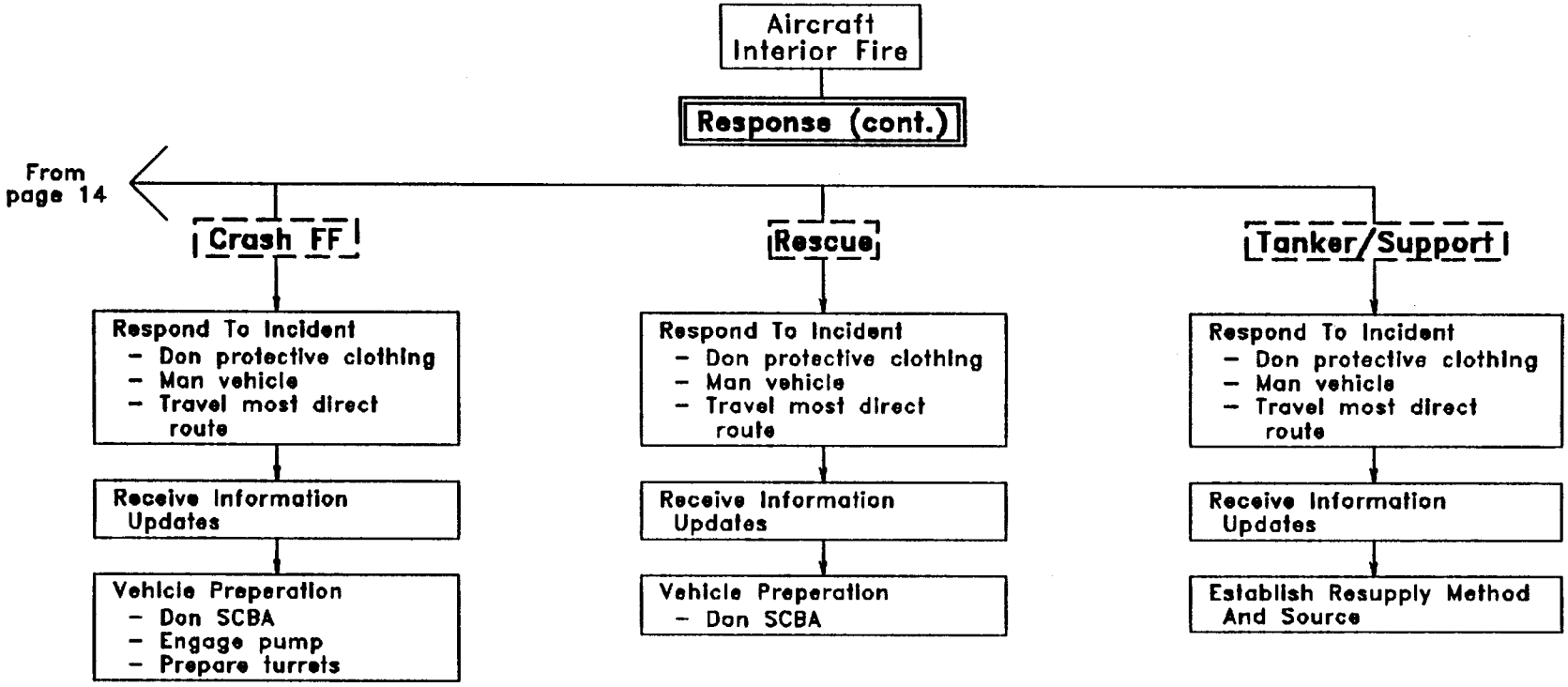
Asst. Chief of Operations (SFO)

- Perform On Scene Size-Up
  - Crash/fire situation
    - ; aircraft type
    - ; fire location/size
    - ; wind speed and direction
  - Hazards
    - ; chemicals/explosives
    - ; fire involvement
  - Rescue
    - ; entry points
    - ; SOB, # and locations
    - ; obstructions
    - ; injured in path
  - Support services
    - ; auxiliary equipment
    - ; base supply/reservice
    - ; mutual aid
- Establish Initial ECP
  - Activate ICS
- Request Additional Support Services
- Direct Vehicle Approach & Positioning

Approach/Position Tasks (A/C Interior Fire)
Level 04

USAF INSTALLATION FIRE DEPARTMENT

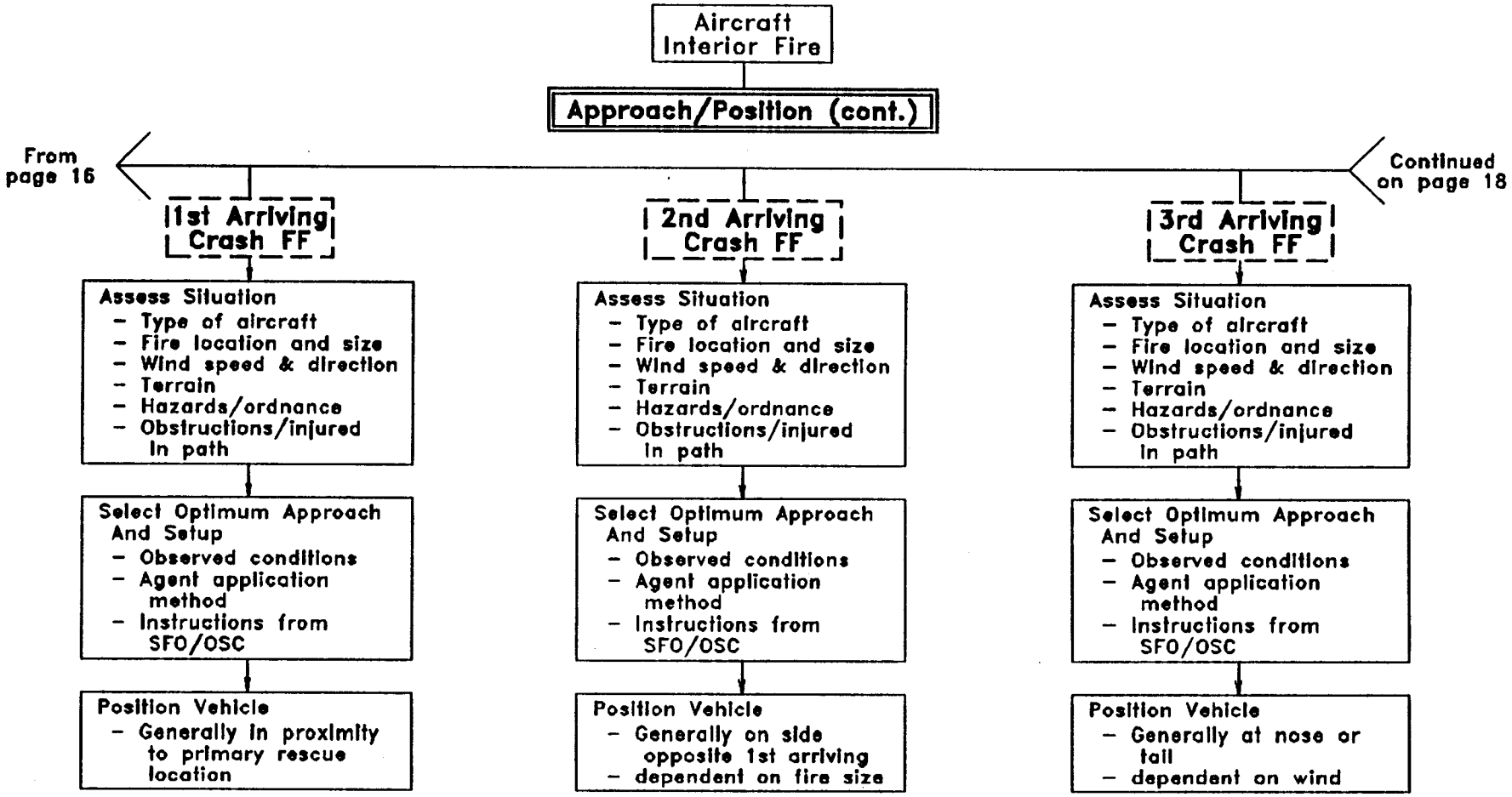
Task Oriented WBS



Response Tasks
(A/C Interior Fire)
Level 04
Page 15 of 00

USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Approach/Position Tasks
(A/C Interior Fire)
Level 04
Page 17 of 00

USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS

Aircraft Interior Fire

Approach/Position (cont.)

From page 17

Continued on page 19

4th Arriving Crash FF

- Assess Situation
  - Type of aircraft
  - Fire location and size
  - Wind speed & direction
  - Terrain
  - Hazards/ordnance
  - Obstructions/injured in path
- Select Optimum Approach And Setup
  - Observed conditions
  - Agent application method
  - Instructions from SFO/OSC
- Position Vehicle
  - As determined by SFO/OSC

Rescue

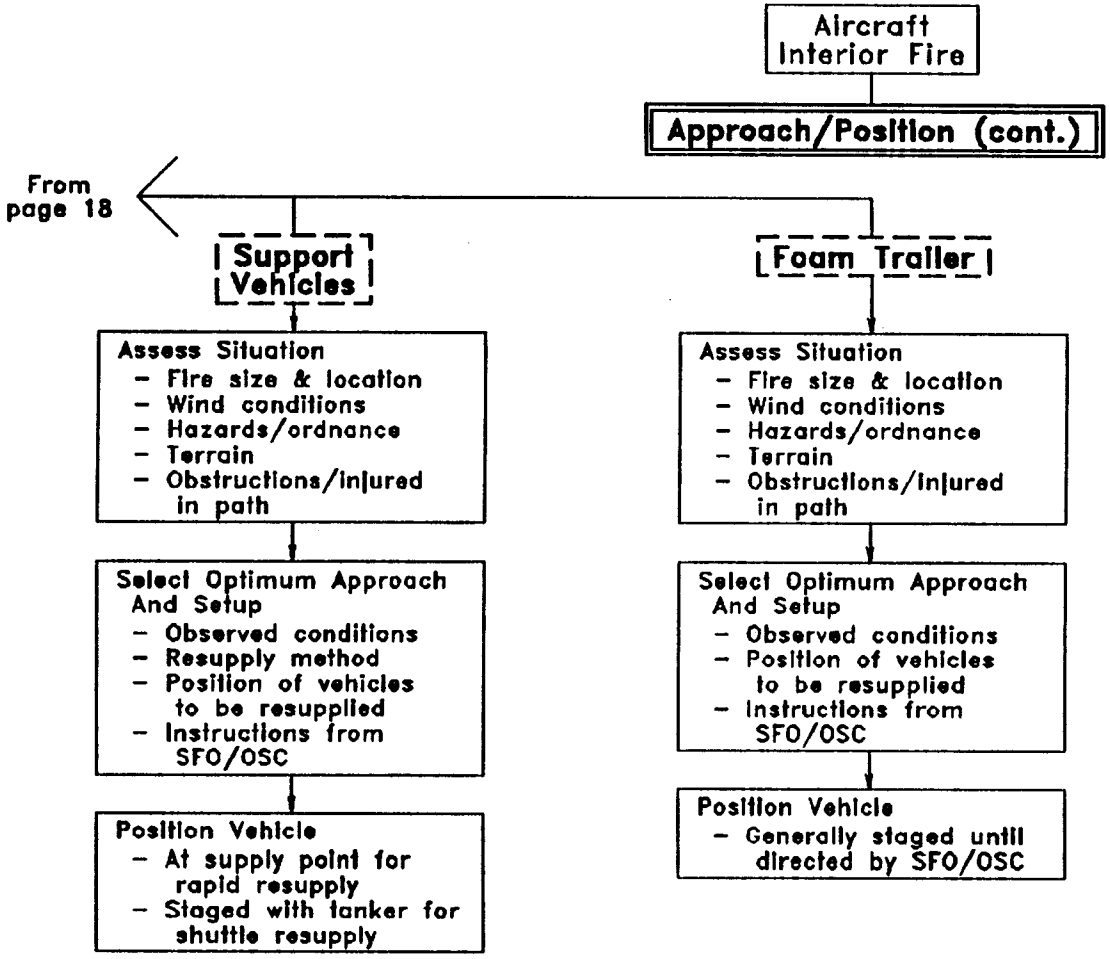
- Assess Situation
  - Type of aircraft
  - Entry points
  - Fire location & size
  - Wind conditions
  - Hazards/ordnance
  - SOB, # and locations
  - Obstructions/injured in path
- Select Optimum Approach And Setup
  - Observed conditions
  - Passenger egress paths
  - Instructions from SFO/OSC
- Position Vehicle
  - based on equipment needs
- Establish Triage Area

Tanker

- Assess Situation
  - Fire size & location
  - Wind conditions
  - Hazards/ordnance
  - Terrain
  - Obstructions/injured in path
- Select Optimum Approach And Setup
  - Observed conditions
  - Resupply method
  - Position of vehicles to be resupplied
  - Instructions from SFO/OSC
- Position Vehicle
  - Generally staged until directed by SFO/OSC

USAF INSTALLATION FIRE DEPARTMENT

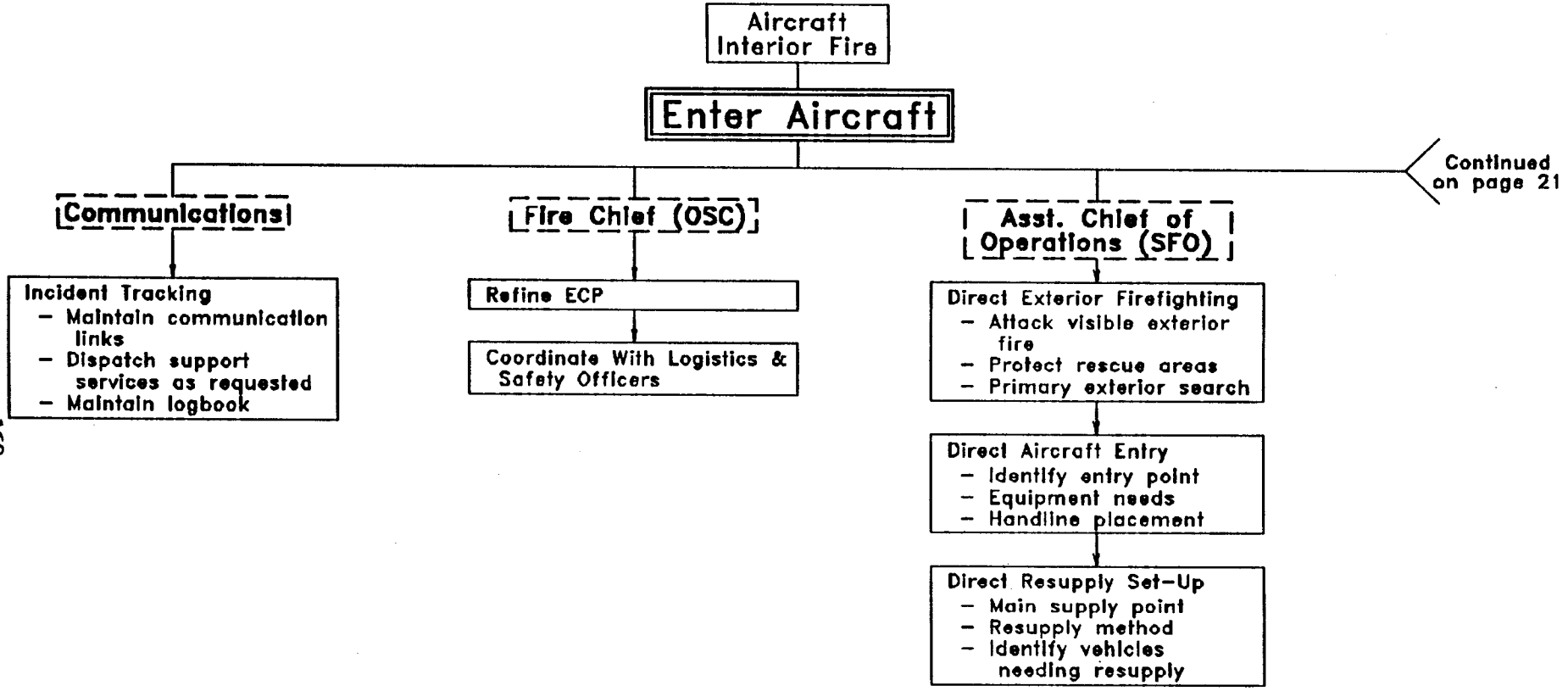
Task Oriented WBS



Approach/Position Tasks
(A/C Interior Fire)
Level 04
Page 19 of 00

USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



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Enter Aircraft Tasks
(A/C Interior Fire)
Level 04
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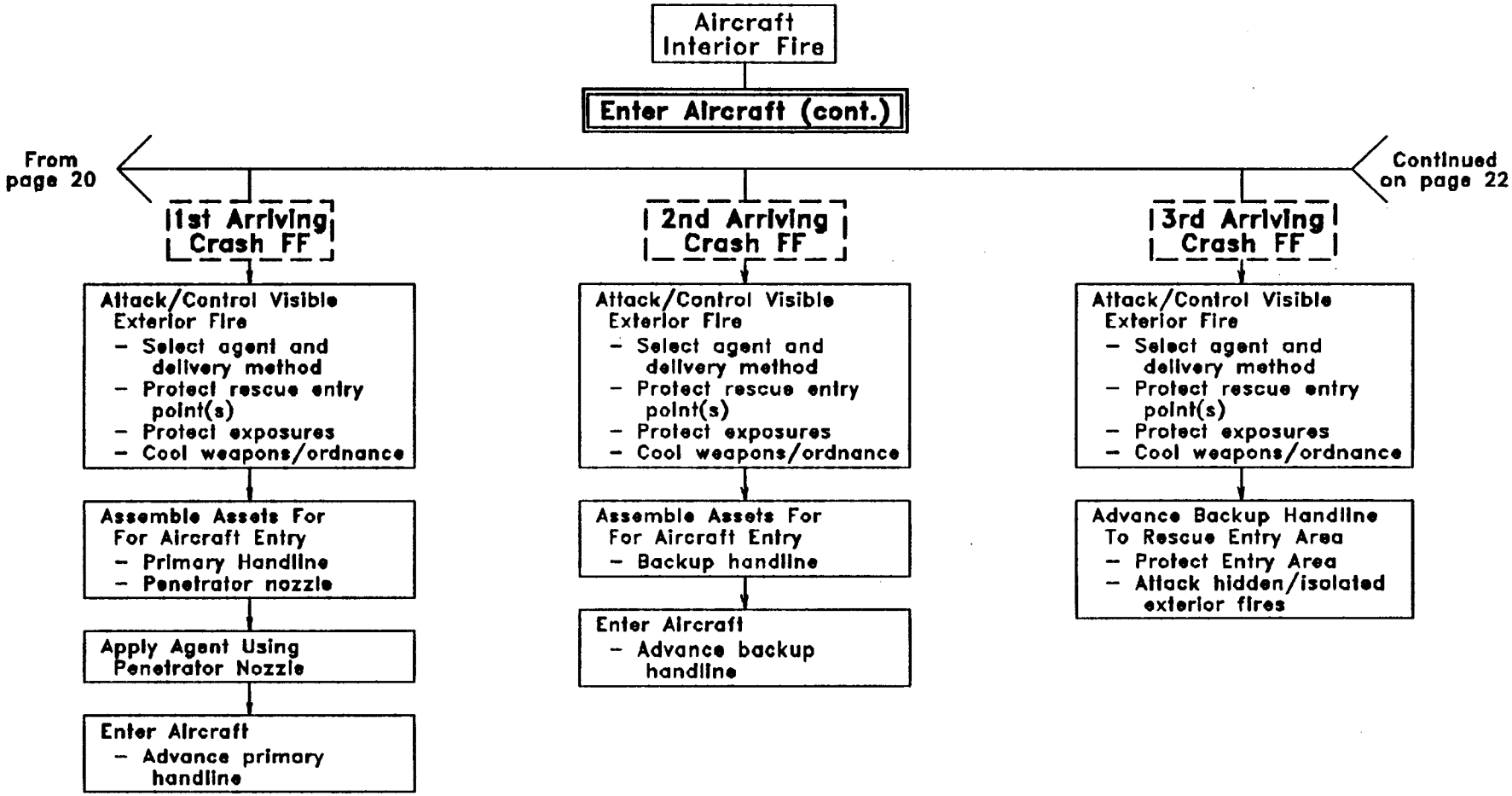
USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Enter Aircraft Tasks
(A/C Interior Fire)
Level 04
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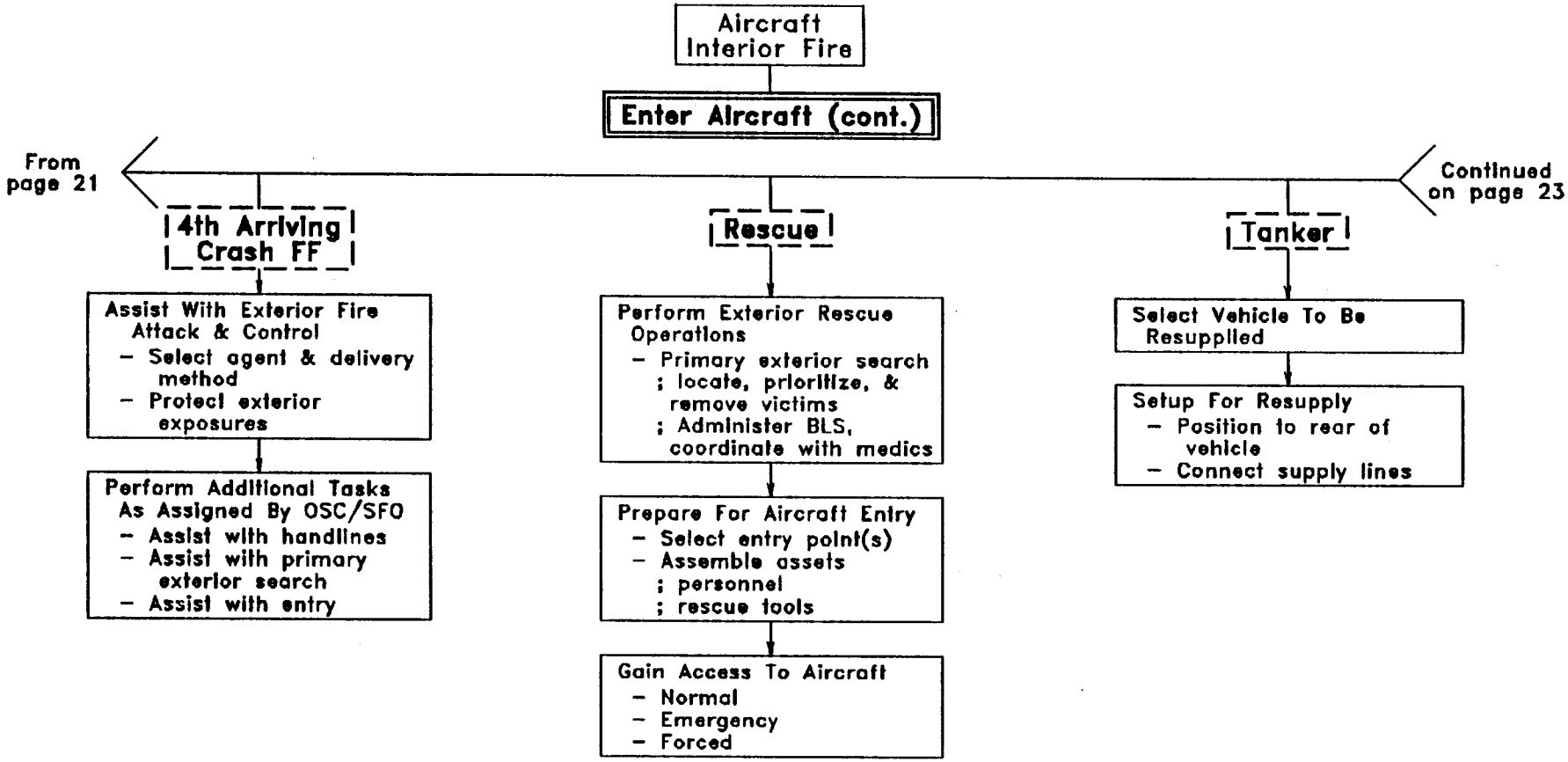
USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Enter Aircraft Tasks
(A/C Interior Fire)
Level 04
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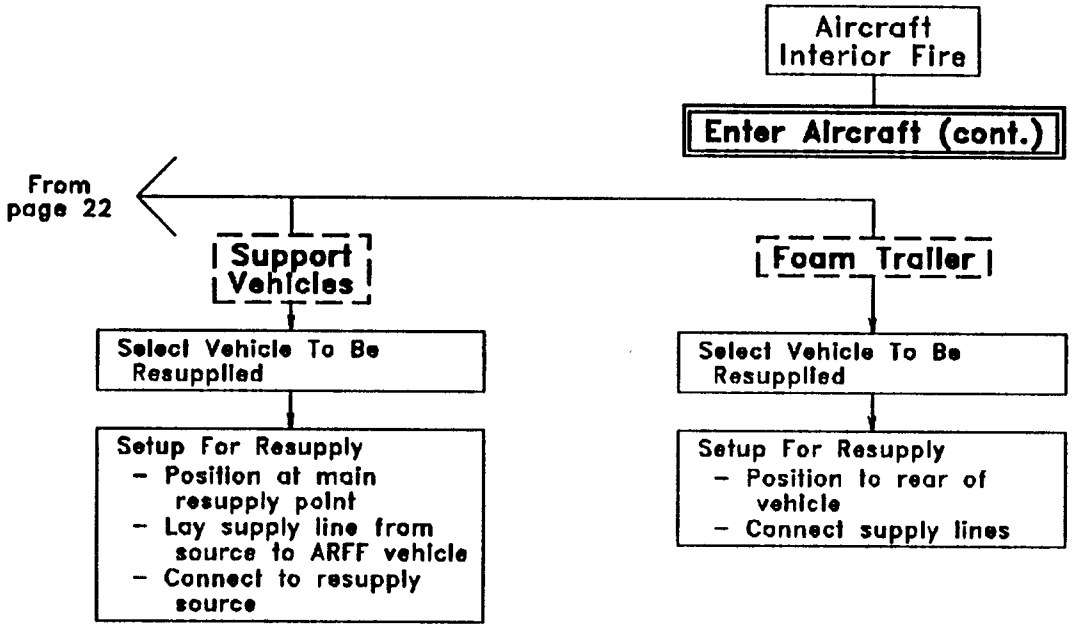
USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Enter Aircraft Tasks
(A/C Interior Fire)
Level 04
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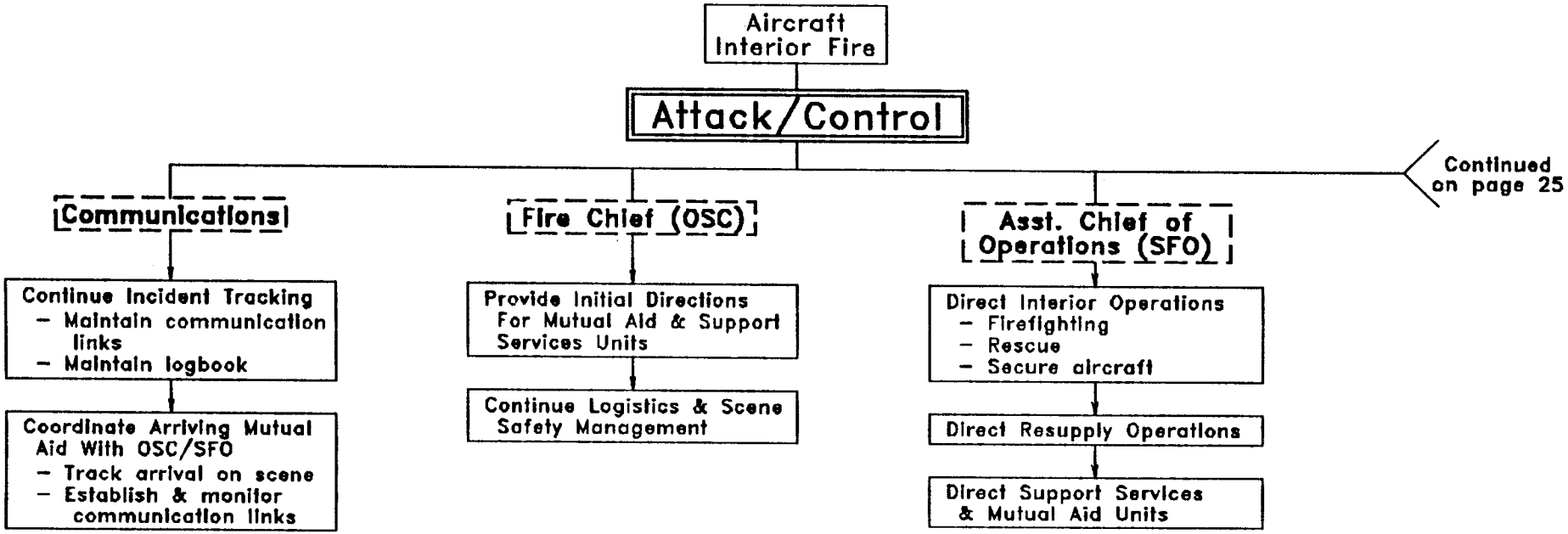
USAF INSTALLATION FIRE DEPARTMENT

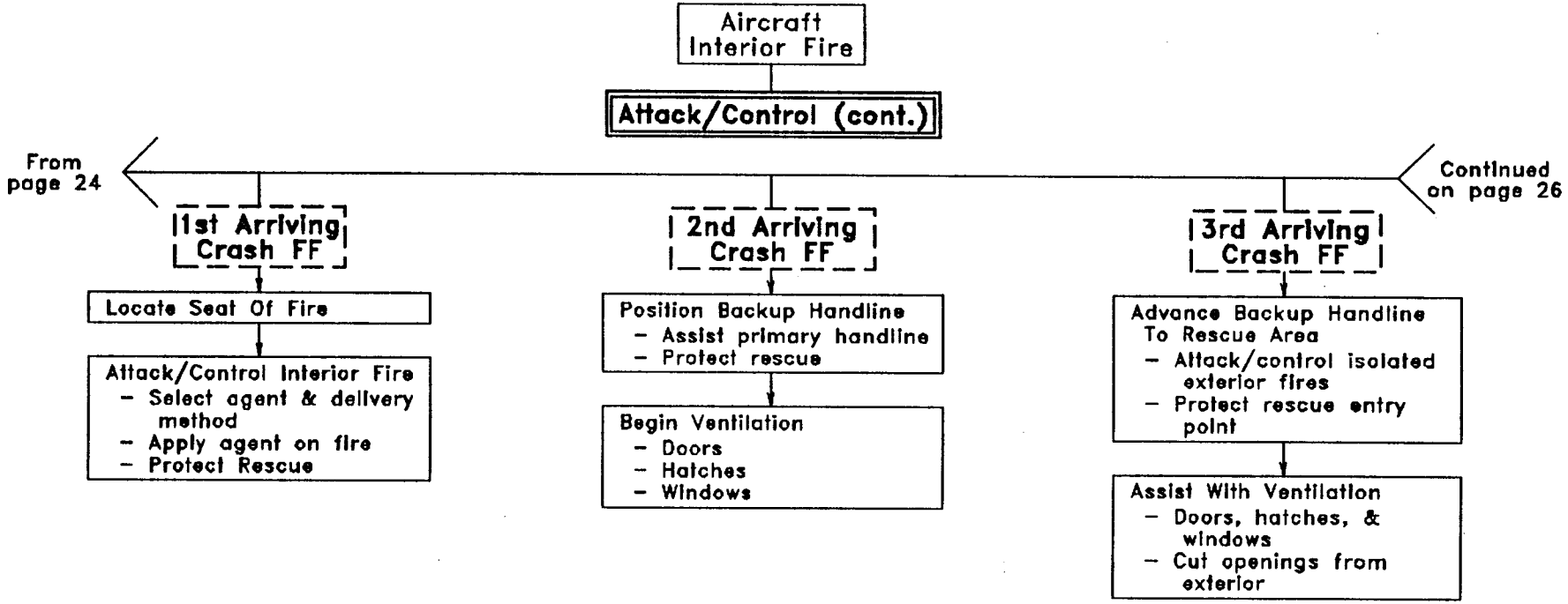
Task Oriented WBS



Attack/Control Tasks
(A/C Interior Fire)
Level 04
Page 24 of 00

USAF INSTALLATION FIRE DEPARTMENT

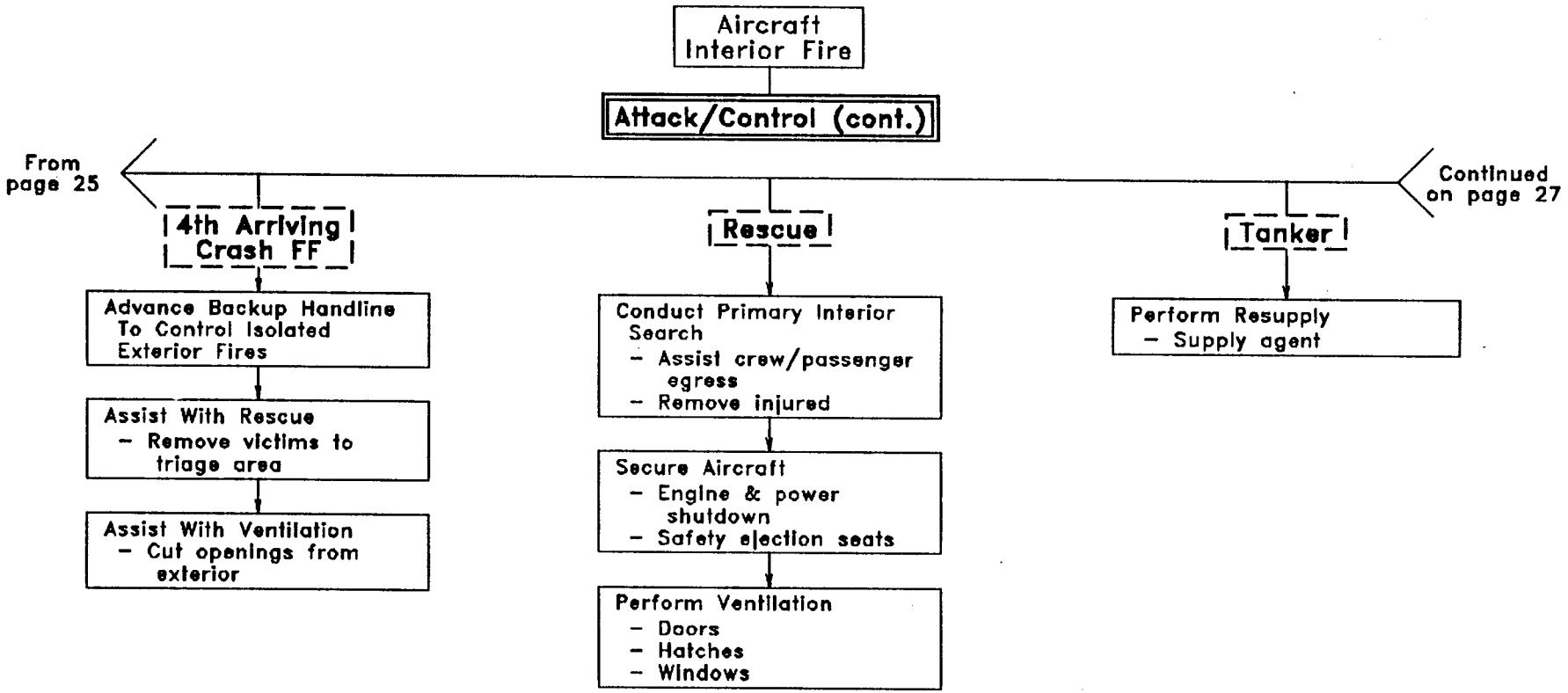
Task Oriented WBS



Attack/Control Tasks
(A/C Interior Fire)
Level 04
Page 25 of 00

USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Attack/Control Tasks
(A/C Interior Fire)
Level 04
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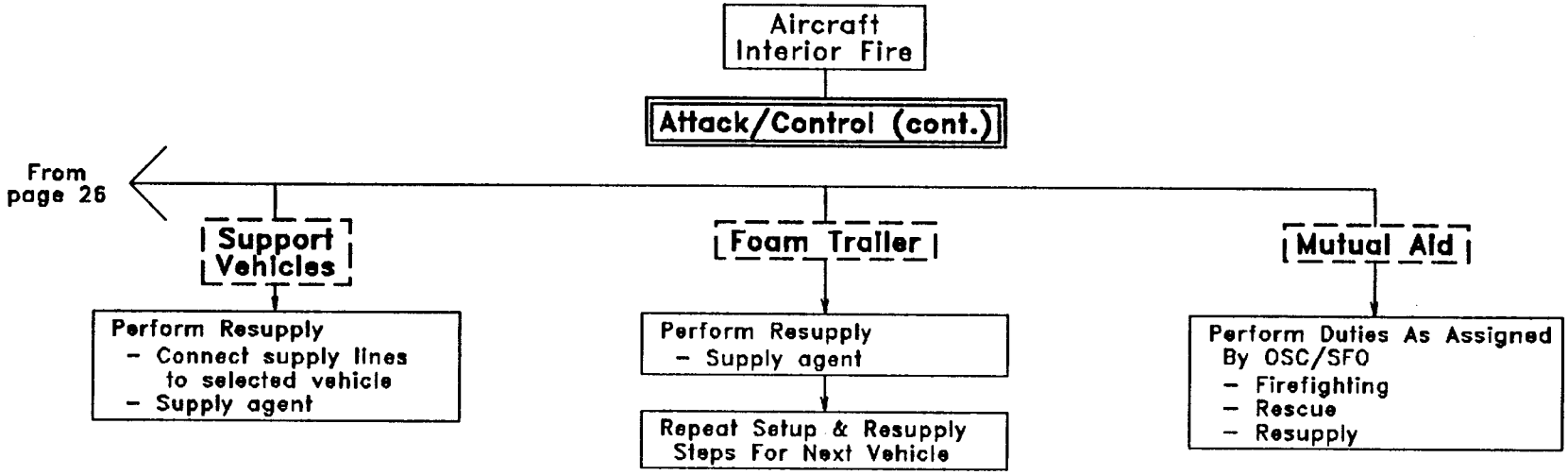
USAF INSTALLATION FIRE DEPARTMENT

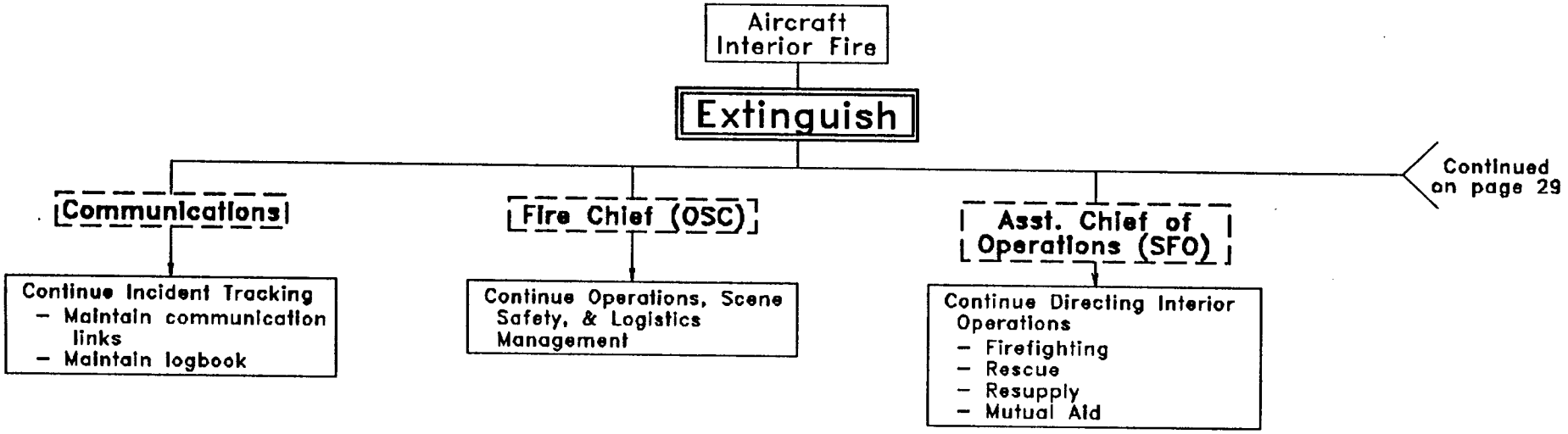
Task Oriented WBS



Attack/Control Tasks
(A/C Interior Fire)
Level 04
Page 27 of 00

USAF INSTALLATION FIRE DEPARTMENT

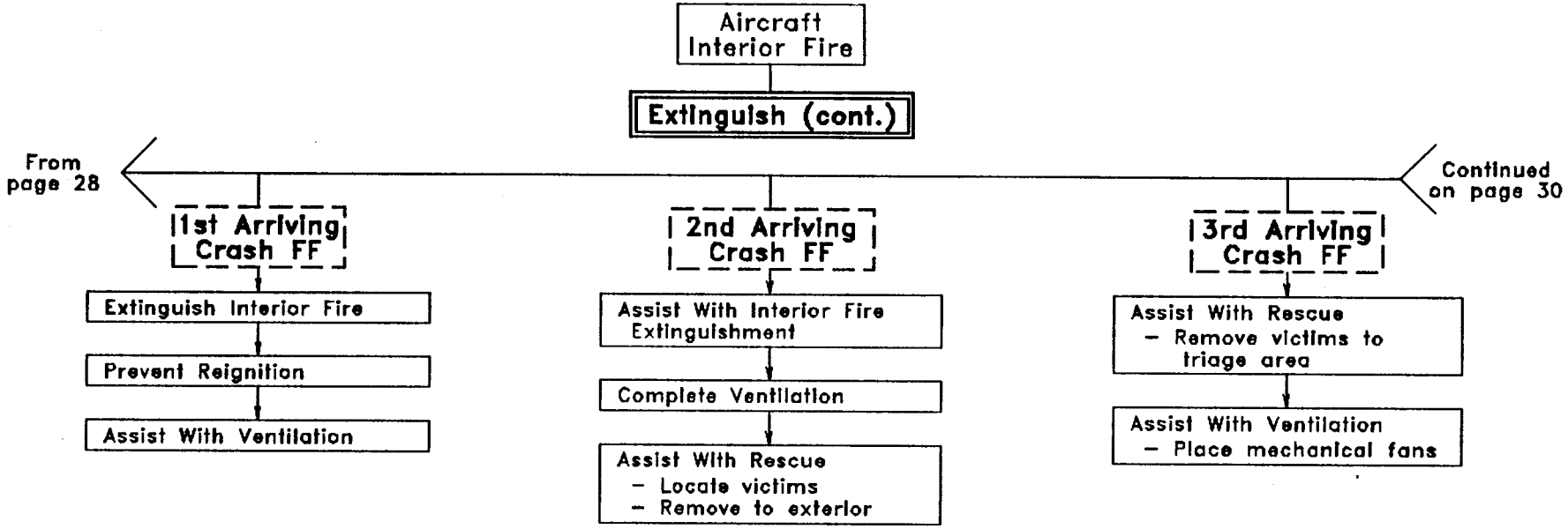
Task Oriented WBS



Extinguish Tasks
(A/C Interior Fire)
Level 04
Page 28 of 00

USAF INSTALLATION FIRE DEPARTMENT

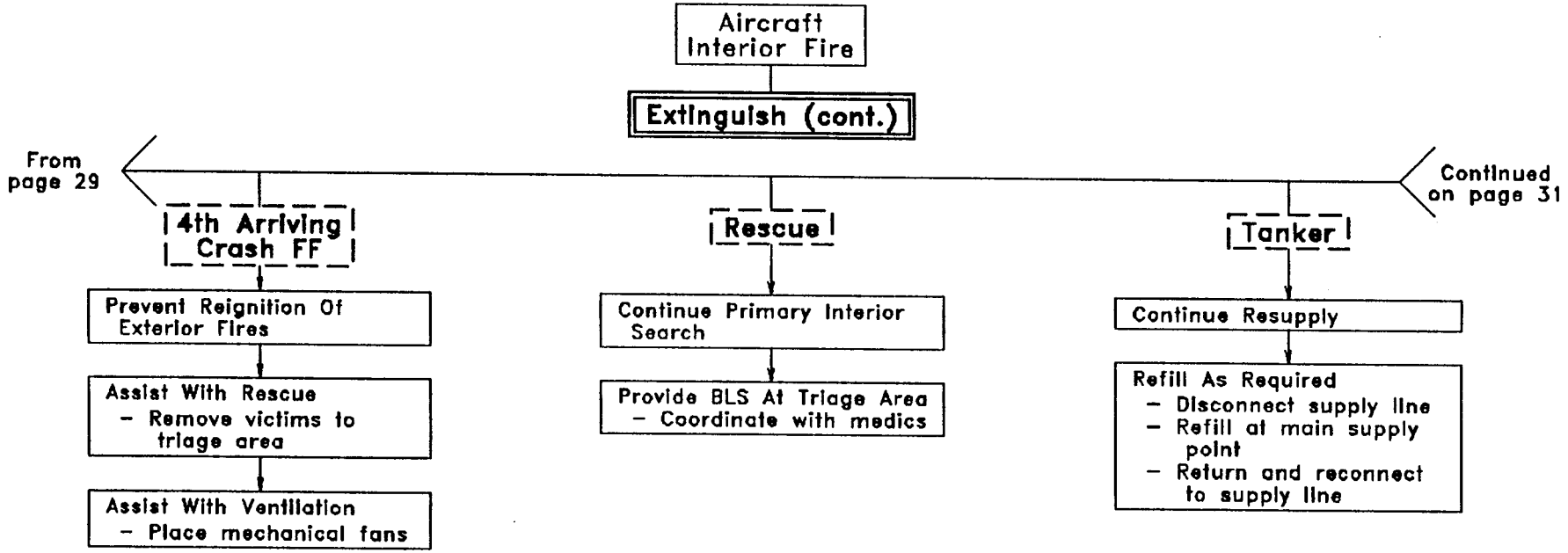
Task Oriented WBS



Extinguish Tasks
(A/C Interior Fire)
Level 04
Page 29 of 00

USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Extinguish Tasks
(A/C Interior Fire)
Level 04
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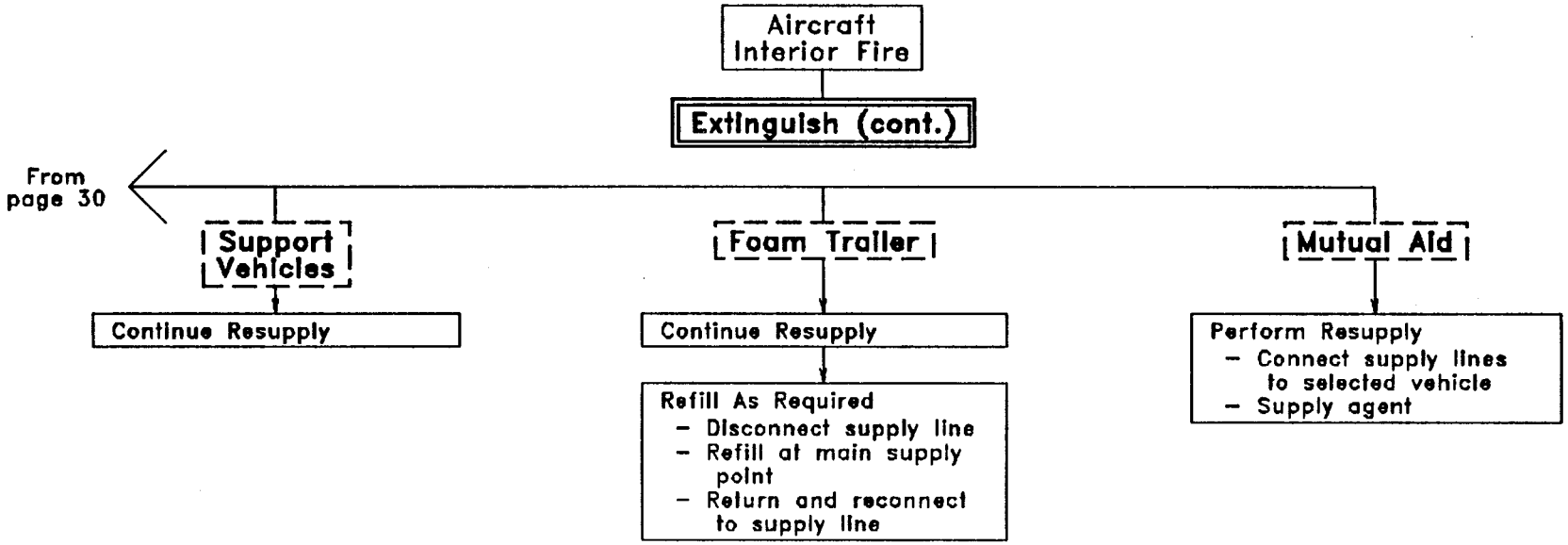
USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Extinguish Tasks
(A/C Interior Fire)
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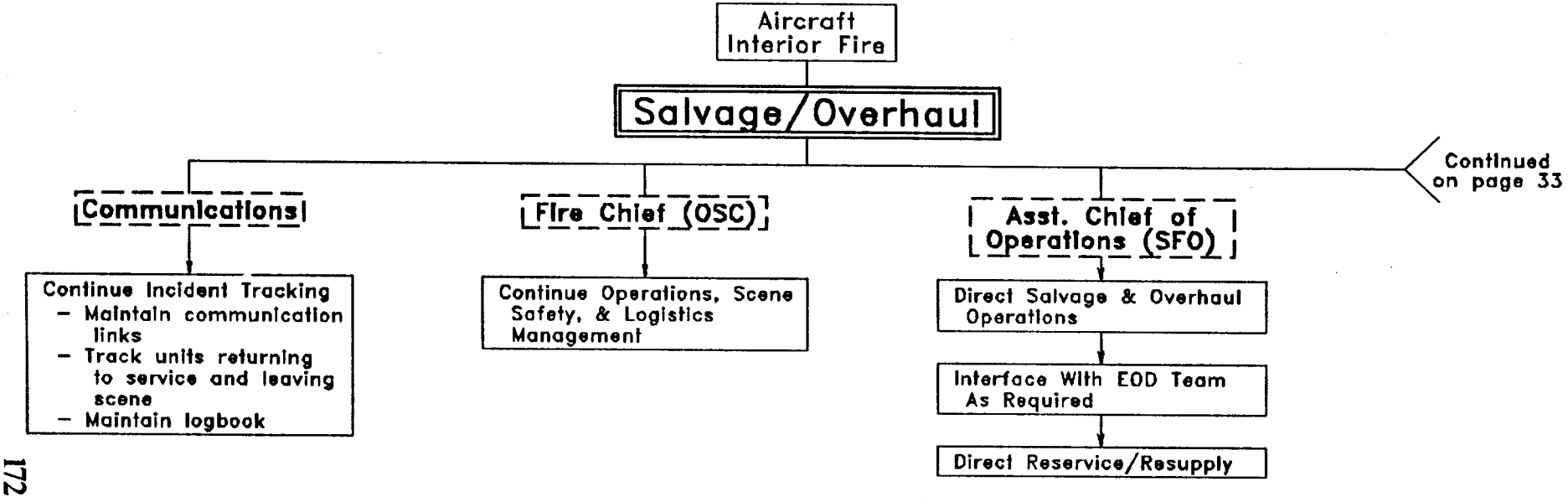
USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Salvage/Overhaul Tasks
(A/C Interior Fire)
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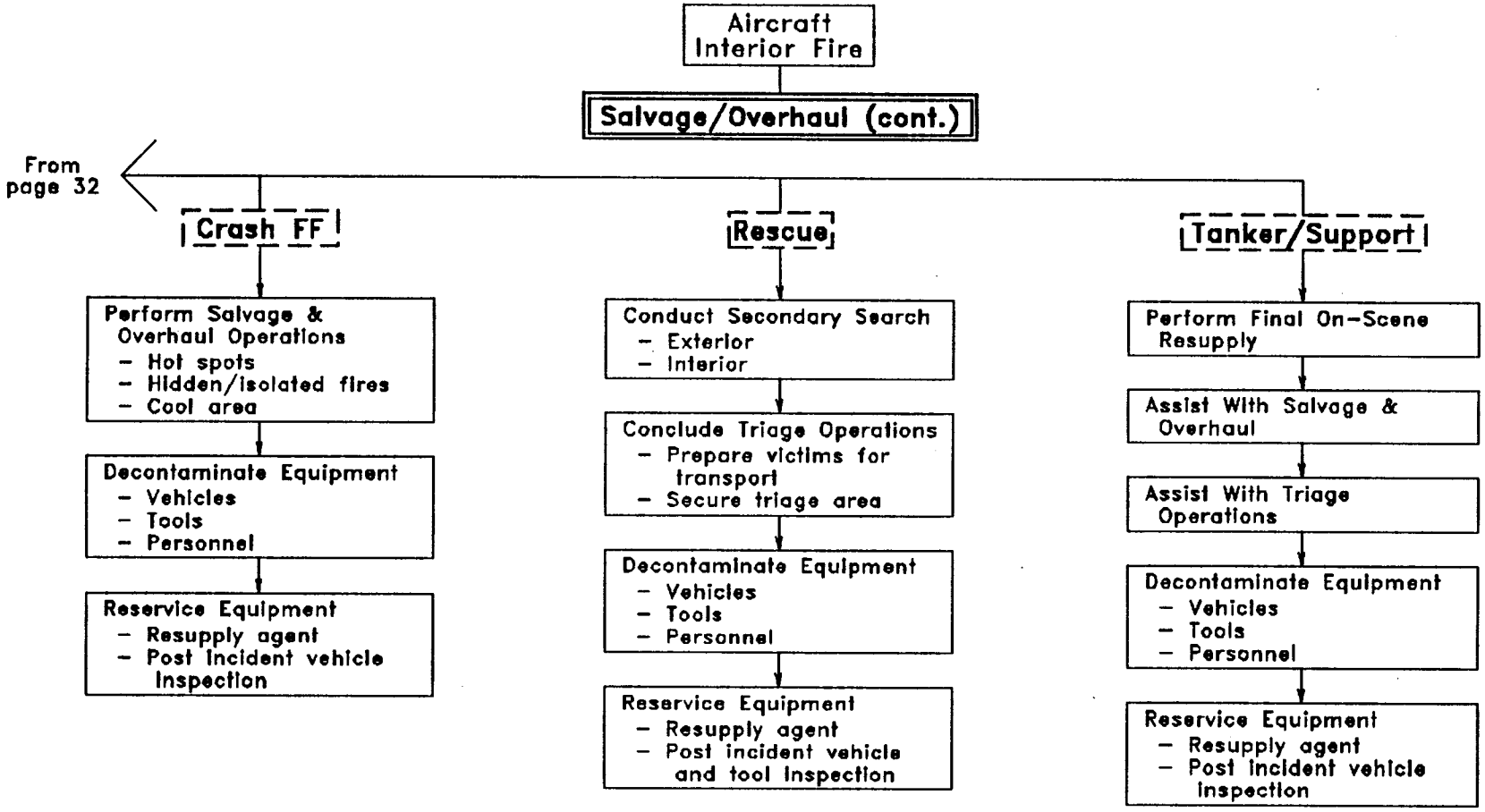
USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Salvage/Overhaul Tasks
(A/C Interior Fire)
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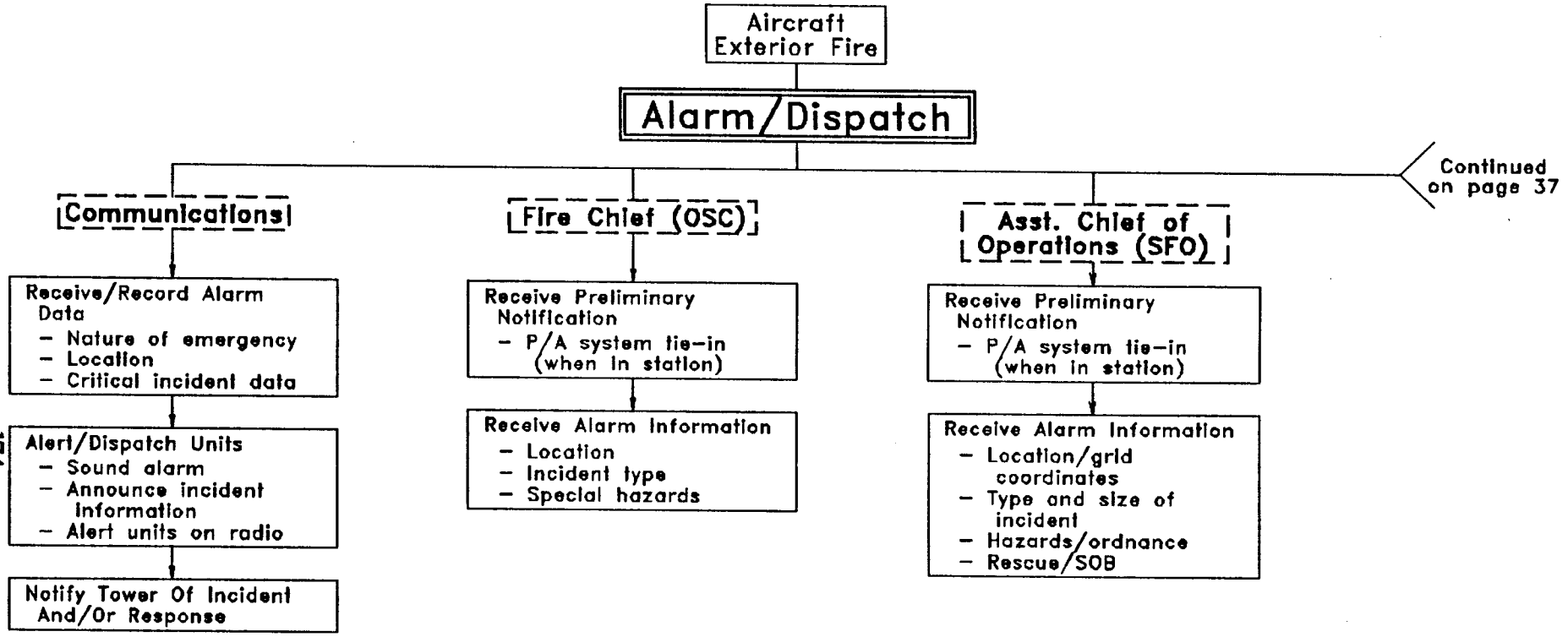
Task Oriented WBS



Alarm/Dispatch Tasks
(A/C Exterior Fire)
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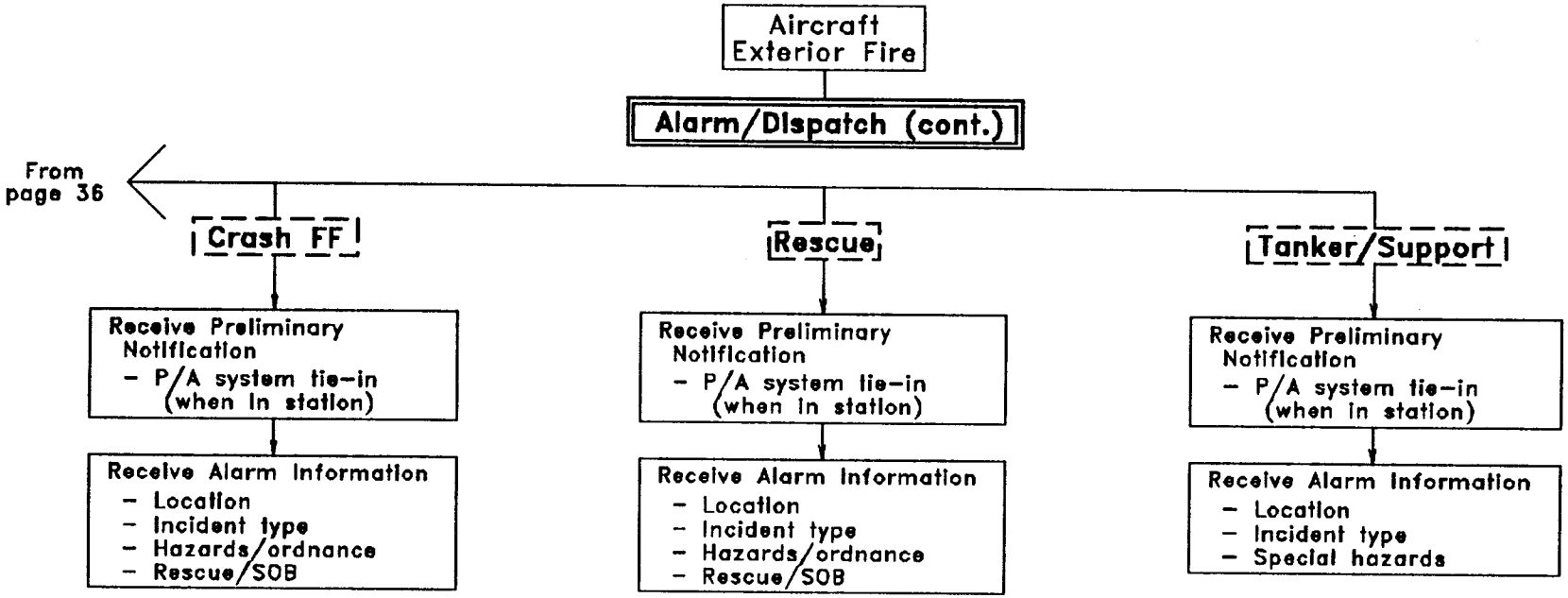
USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Alarm/Dispatch Tasks
(A/C Exterior Fire)
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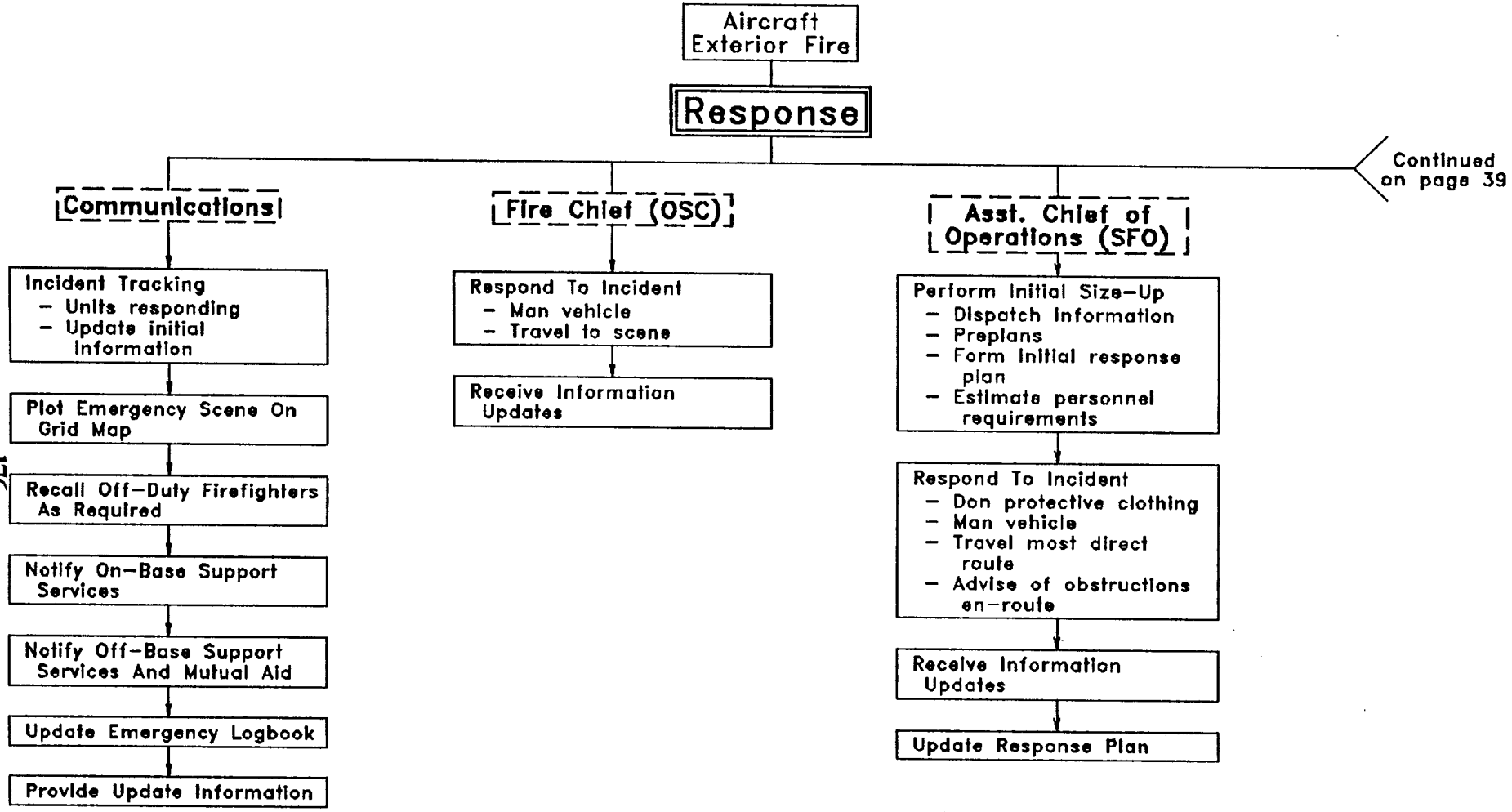
USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Response Tasks
(A/C Exterior Fire)
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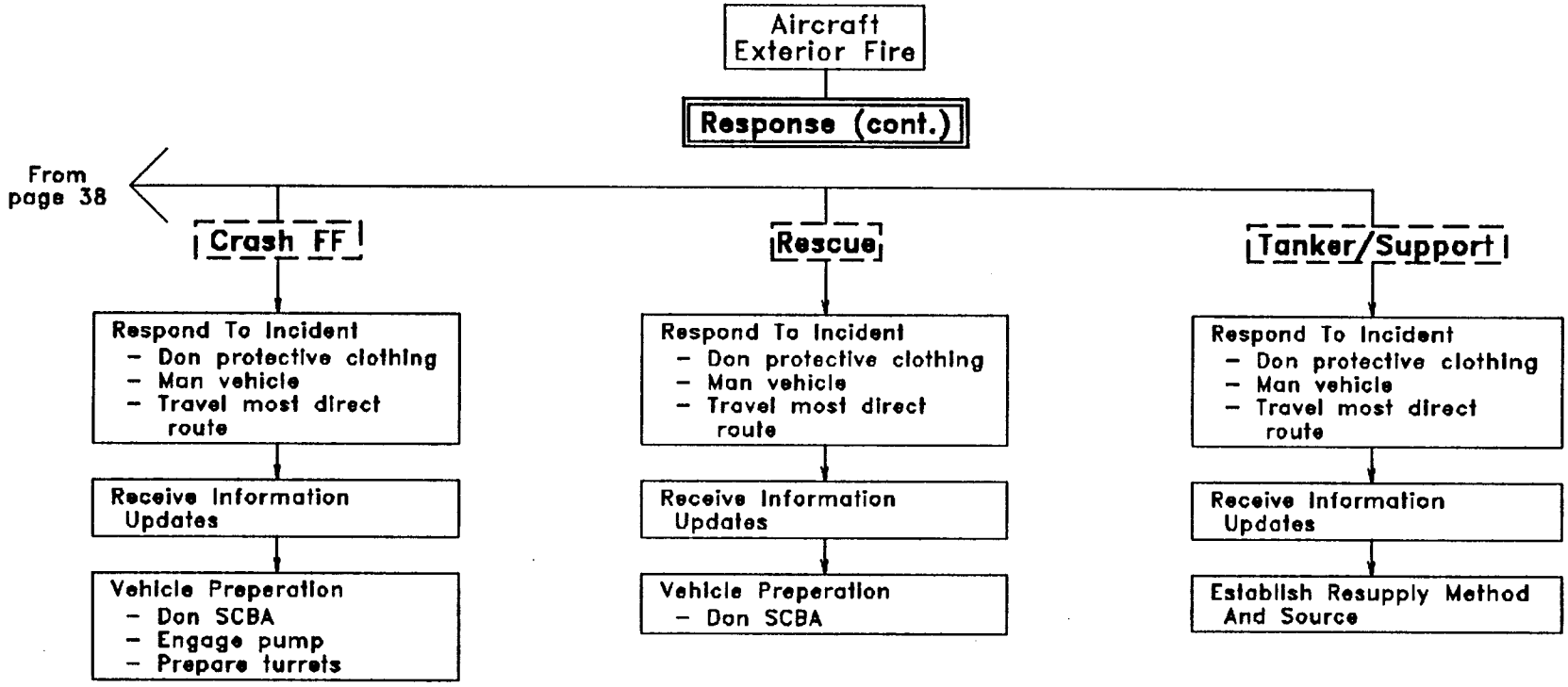
USAF INSTALLATION FIRE DEPARTMENT

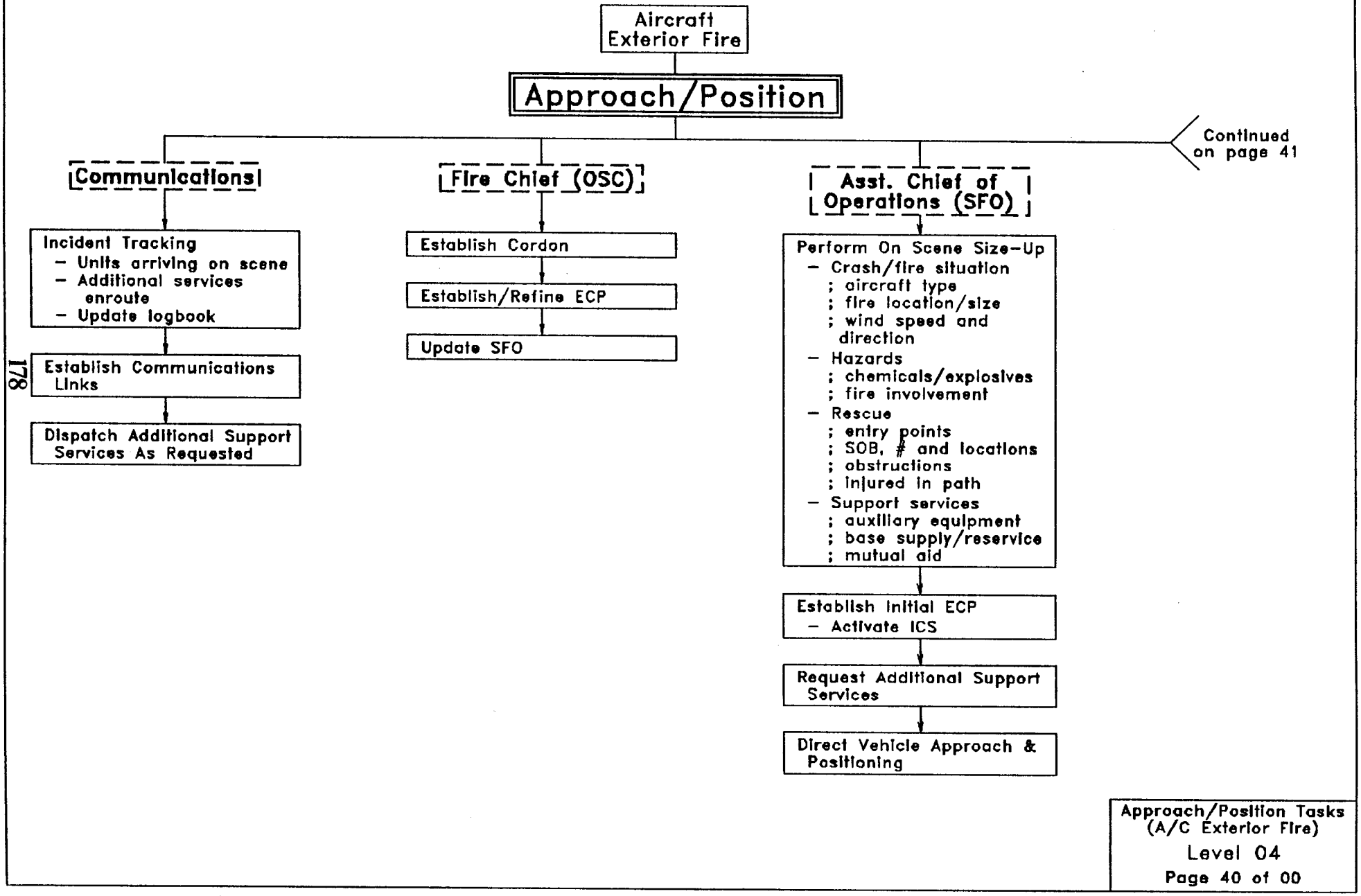
Task Oriented WBS



Response Tasks
(A/C Exterior Fire)
Level 04

USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



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Approach/Position Tasks
(A/C Exterior Fire)
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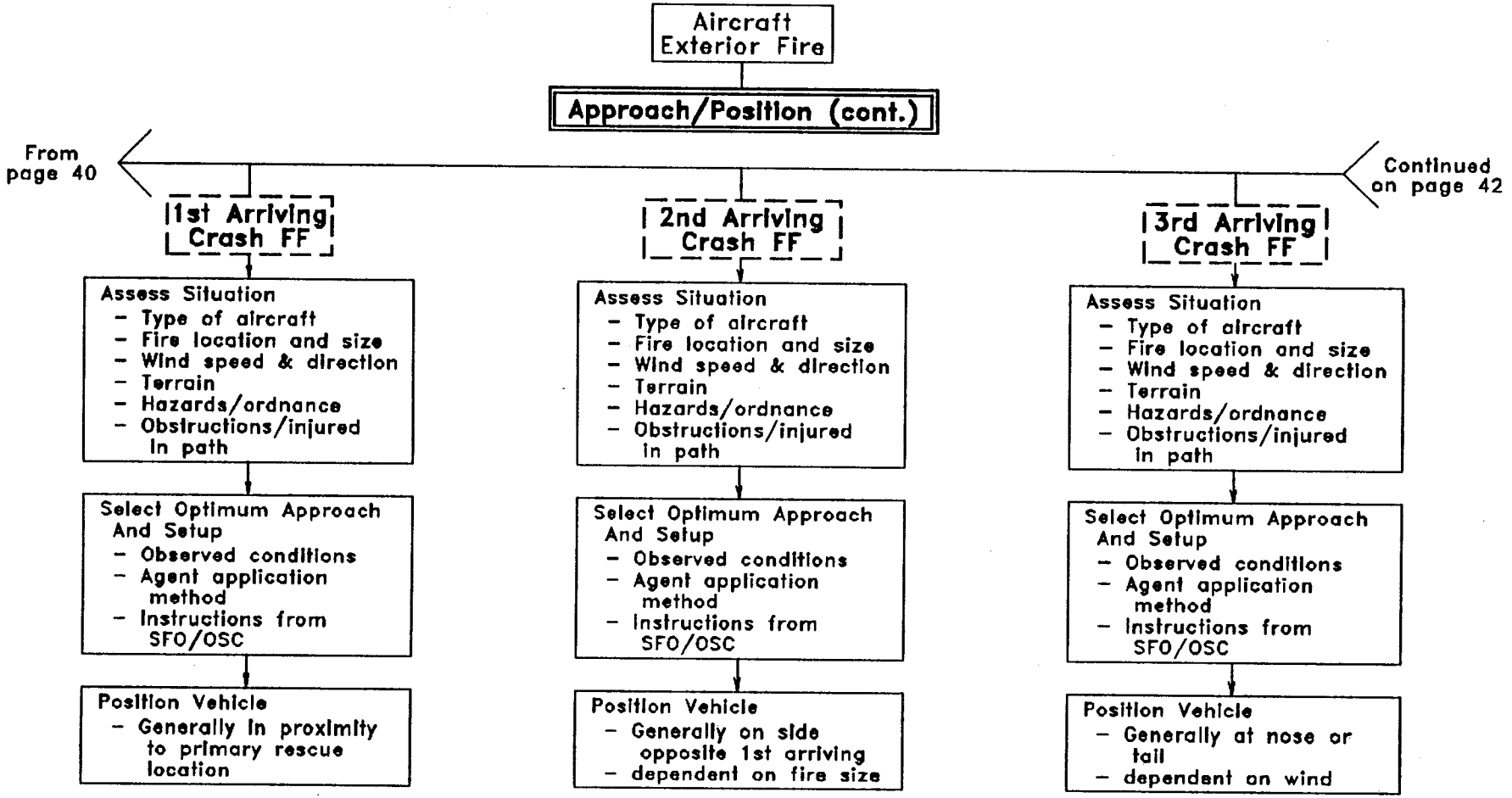
USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Approach/Position Tasks
(A/C Exterior Fire)
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USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS

Aircraft Exterior Fire

Approach/Position (cont.)

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Continued on page 43

4th Arriving Crash FF

- Assess Situation
  - Type of aircraft
  - Fire location and size
  - Wind speed & direction
  - Terrain
  - Hazards/ordnance
  - Obstructions/injured in path
- Select Optimum Approach And Setup
  - Observed conditions
  - Agent application method
  - Instructions from SFO/OSC
- Position Vehicle
  - As determined by SFO/OSC

Rescue

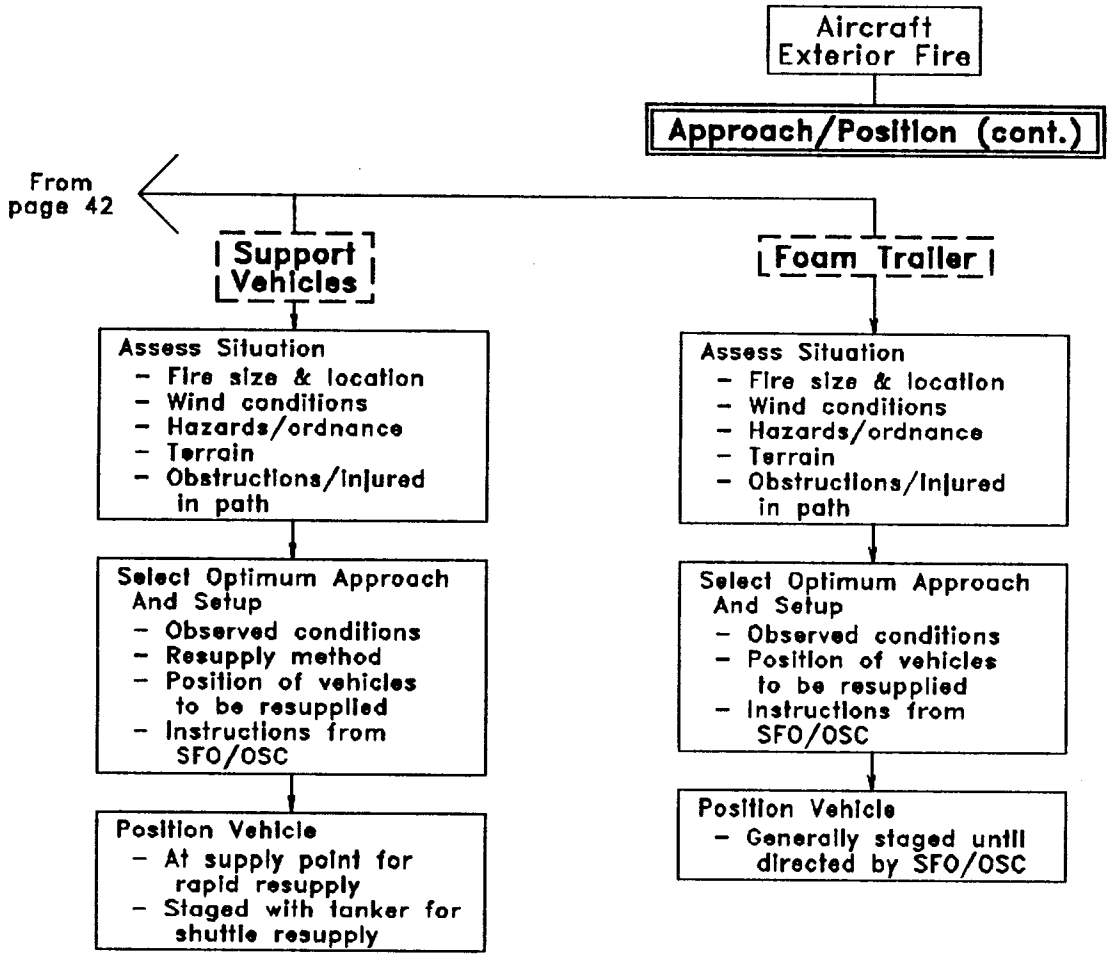
- Assess Situation
  - Type of aircraft
  - Entry points
  - Fire location & size
  - Wind conditions
  - Hazards/ordnance
  - SOB, # and locations
  - Obstructions/injured in path
- Select Optimum Approach And Setup
  - Observed conditions
  - Passenger egress paths
  - Instructions from SFO/OSC
- Position Vehicle
  - based on equipment needs
- Establish Triage Area

Tanker

- Assess Situation
  - Fire size & location
  - Wind conditions
  - Hazards/ordnance
  - Terrain
  - Obstructions/injured in path
- Select Optimum Approach And Setup
  - Observed conditions
  - Resupply method
  - Position of vehicles to be resupplied
  - Instructions from SFO/OSC
- Position Vehicle
  - Generally staged until directed by SFO/OSC

USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Approach/Position Tasks
(A/C Exterior Fire)
Level 04
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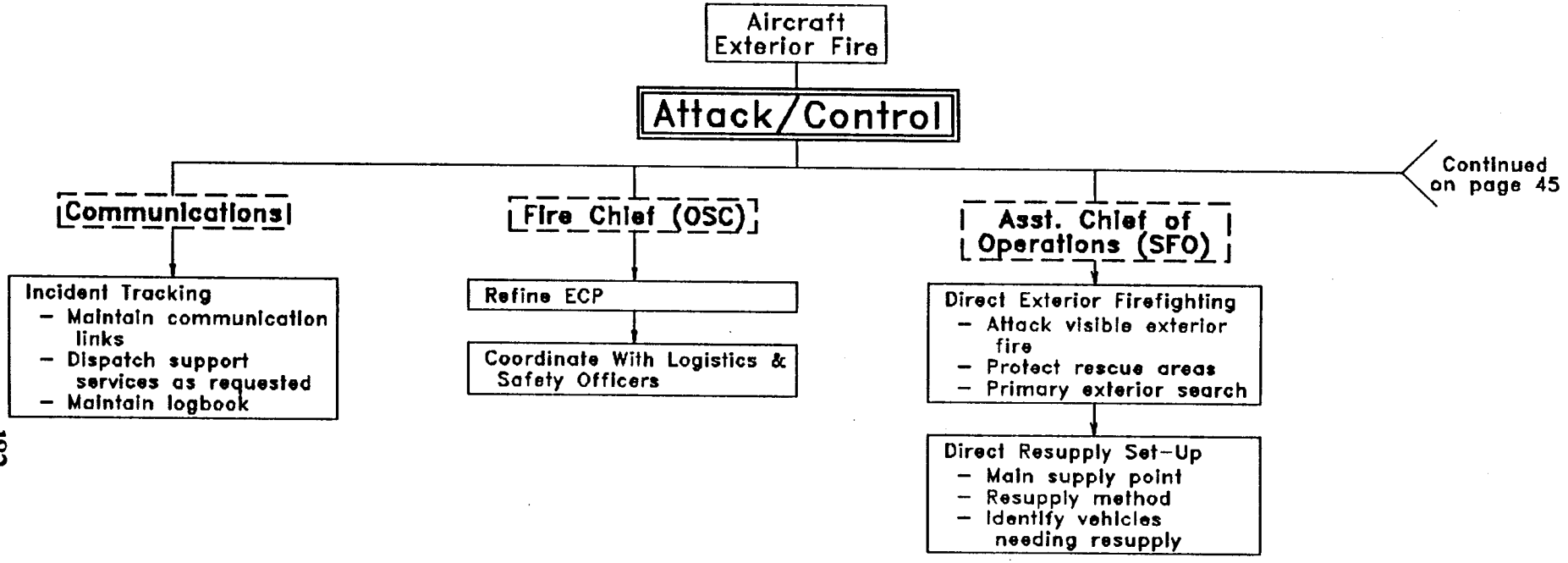
USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Attack/Control Tasks
(A/C Exterior Fire)
Level 04
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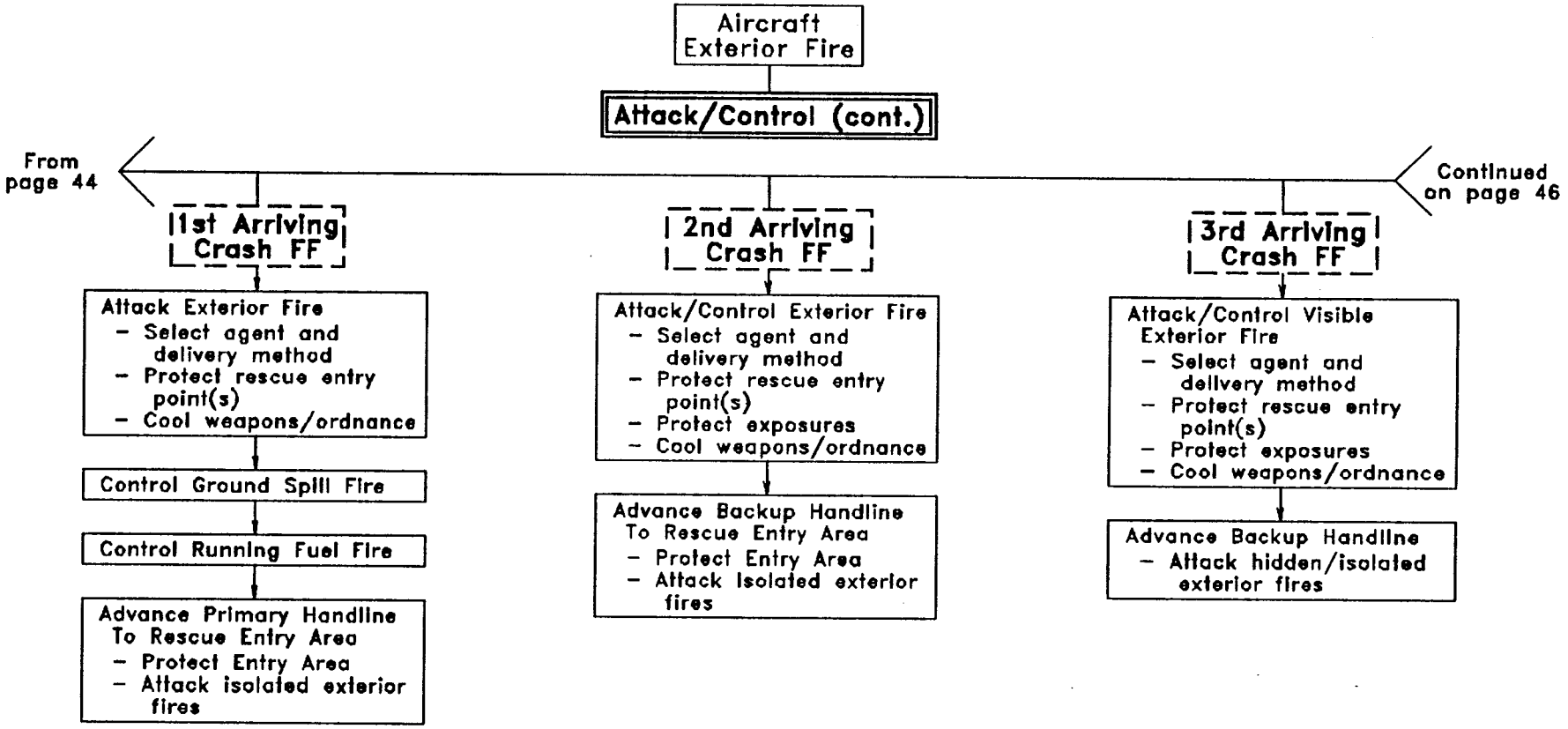
USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Attack/Control Tasks
(A/C Exterior Fire)
Level 04
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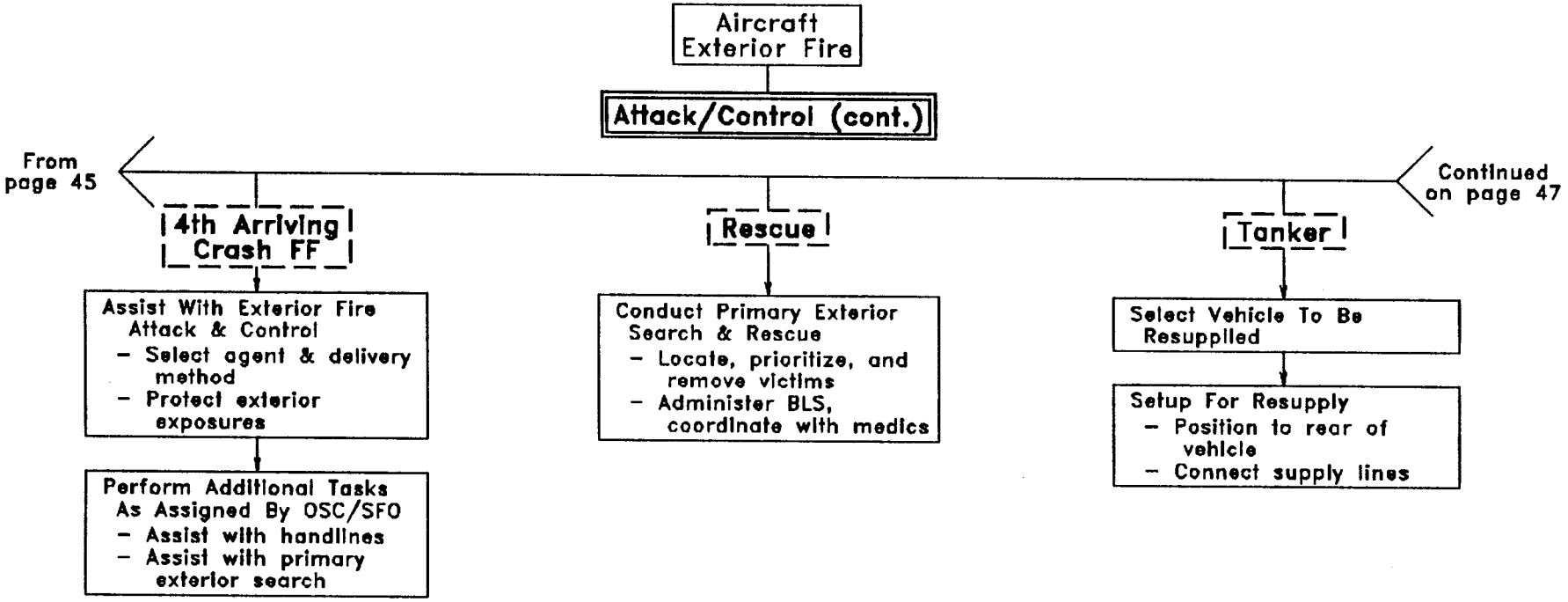
USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Attack/Control Tasks
(A/C Exterior Fire)
Level 04
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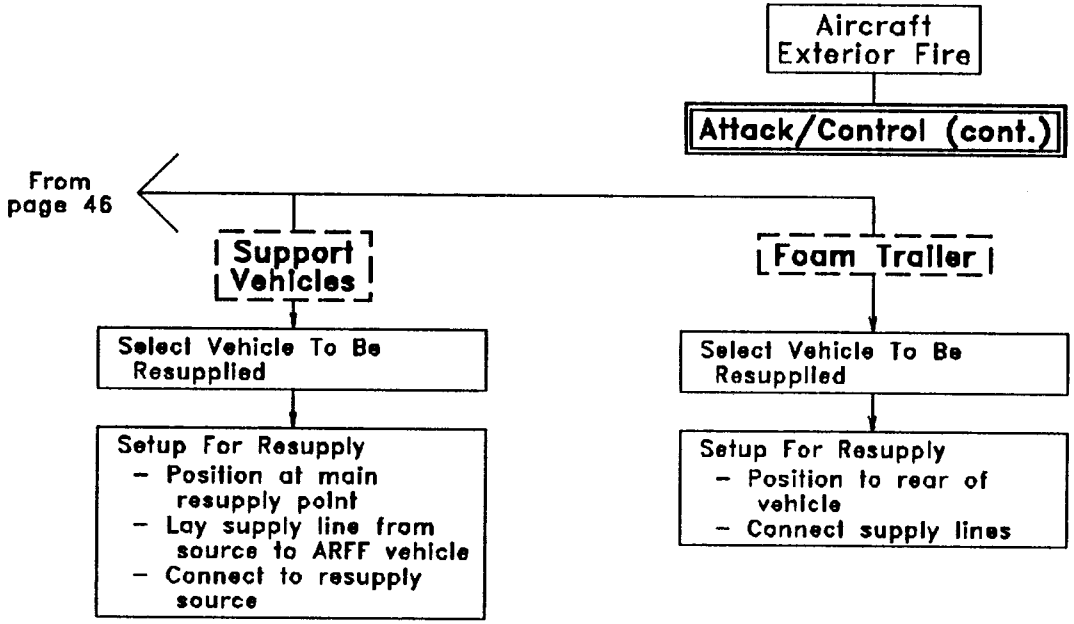
USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Attack/Control Tasks
(A/C Exterior Fire)
Level 04
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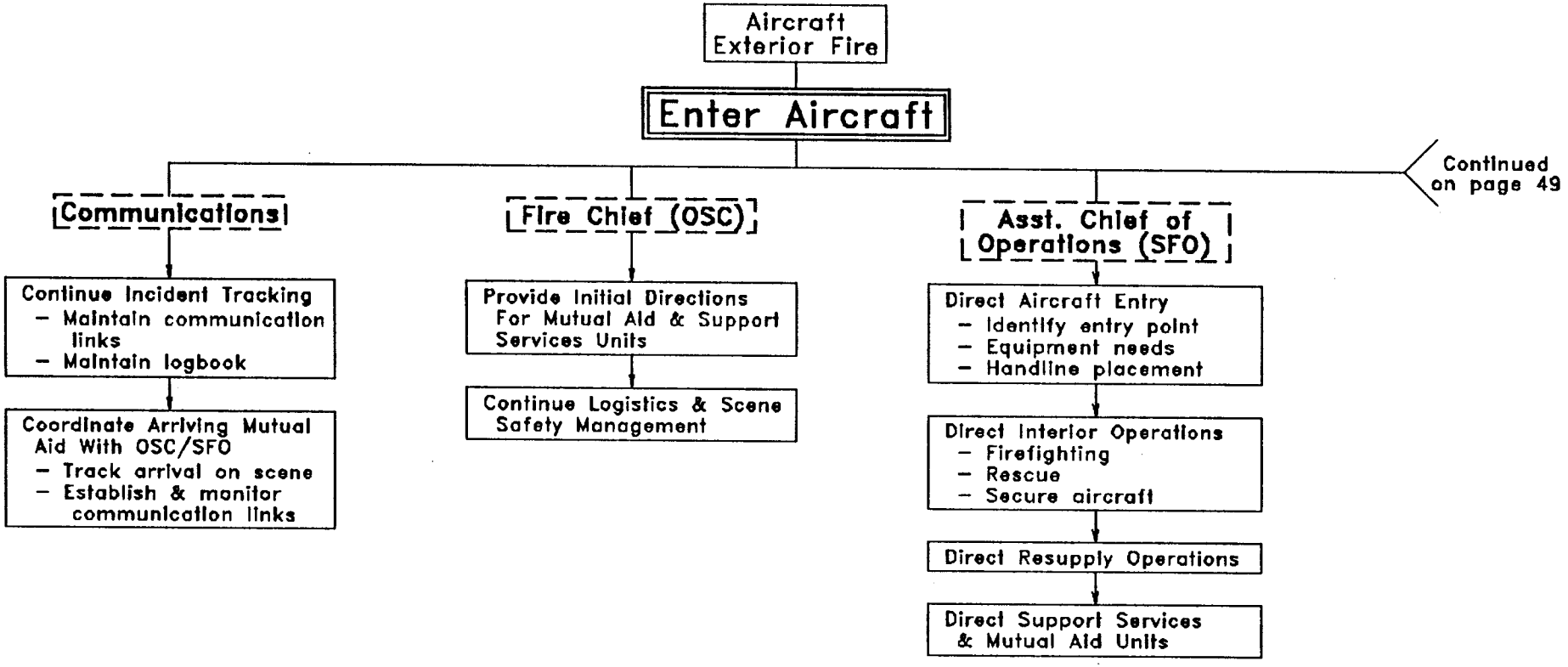
USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Enter Aircraft Tasks
(A/C Exterior Fire)
Level 04
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USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS

Aircraft Exterior Fire

Enter Aircraft (cont.)

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Continued on page 50

1st Arriving Crash FF

- Assemble Assets For For Aircraft Entry
  - Primary Handline
  - Penetrator nozzle
- Apply Agent Using Penetrator Nozzle
- Enter Aircraft
  - Advance primary handline
- Attack/Control Interior Fire Extension
  - Select agent & delivery method
  - Apply agent on fire
  - Protect Rescue

2nd Arriving Crash FF

- Assemble Assets For For Aircraft Entry
  - Backup handline
- Enter Aircraft
  - Advance backup handline
- Position Backup Handline
  - Assist primary handline
  - Protect rescue
- Begin Ventilation
  - Doors
  - Hatches
  - Windows

3rd Arriving Crash FF

- Position Backup Handline At Rescue Area
  - Protect rescue entry point
  - Attack/control isolated exterior fires
- Assist With Ventilation
  - Doors, hatches, & windows
  - Cut openings from exterior

Enter Aircraft Tasks (A/C Exterior Fire)
Level 04
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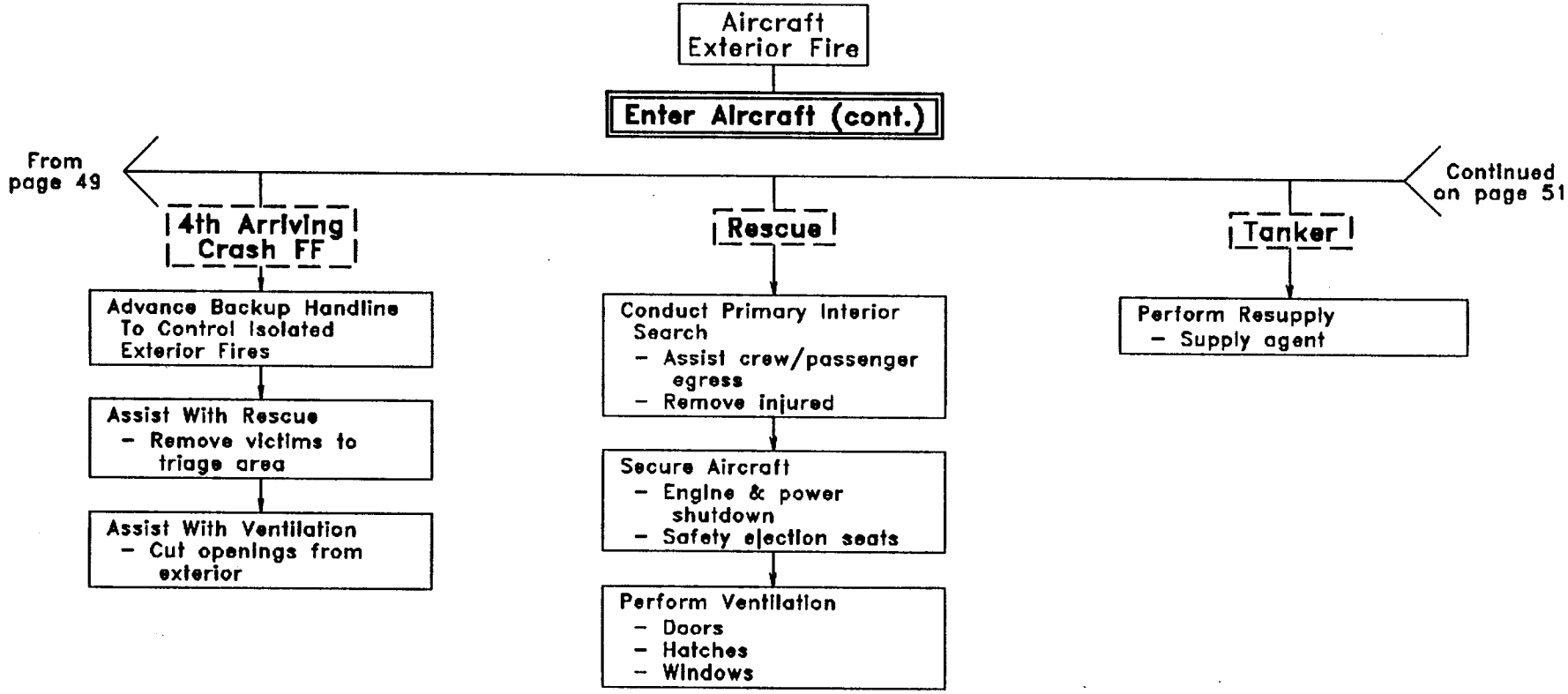
USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Enter Aircraft Tasks
(A/C Exterior Fire)
Level 04
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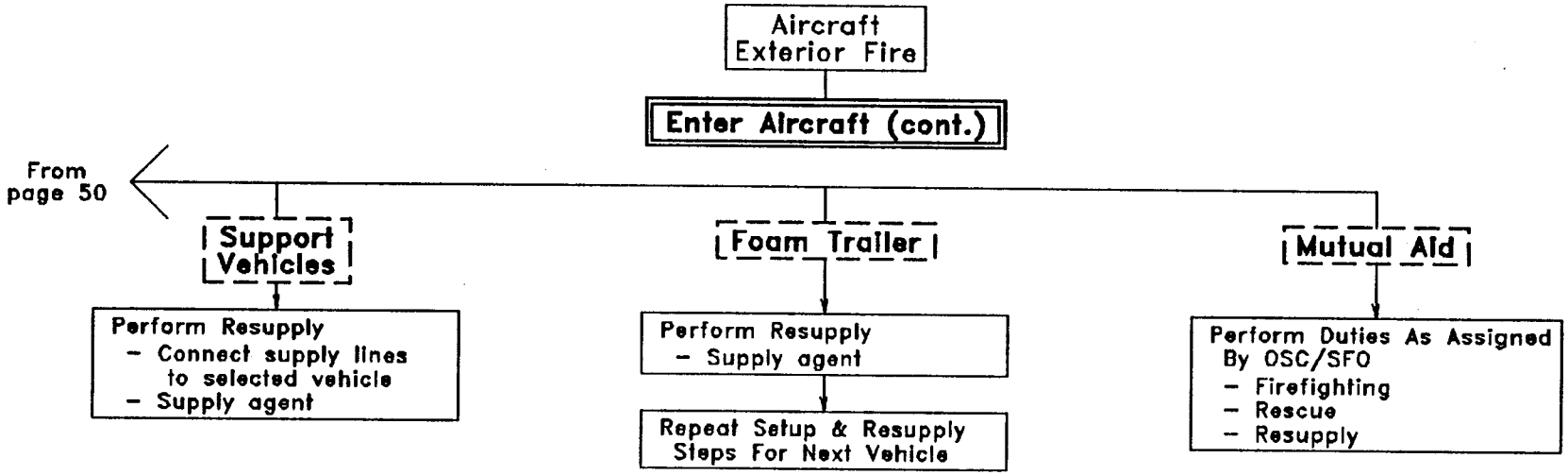
USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Enter Aircraft Tasks
(A/C Exterior Fire)
Level 04
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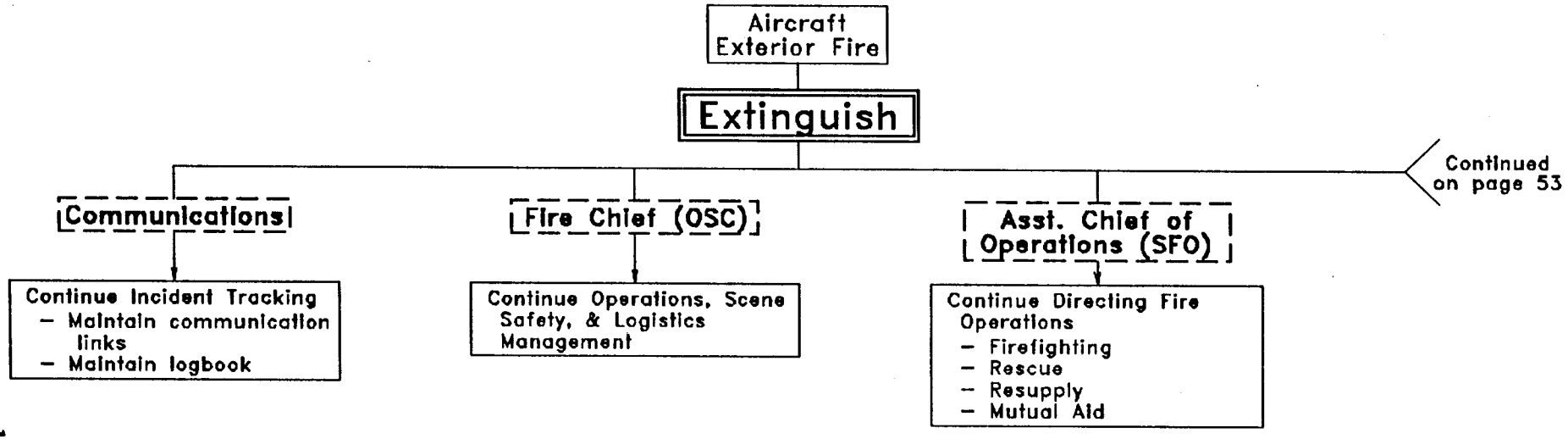
USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Extinguish Tasks
(A/C Exterior Fire)
Level 04
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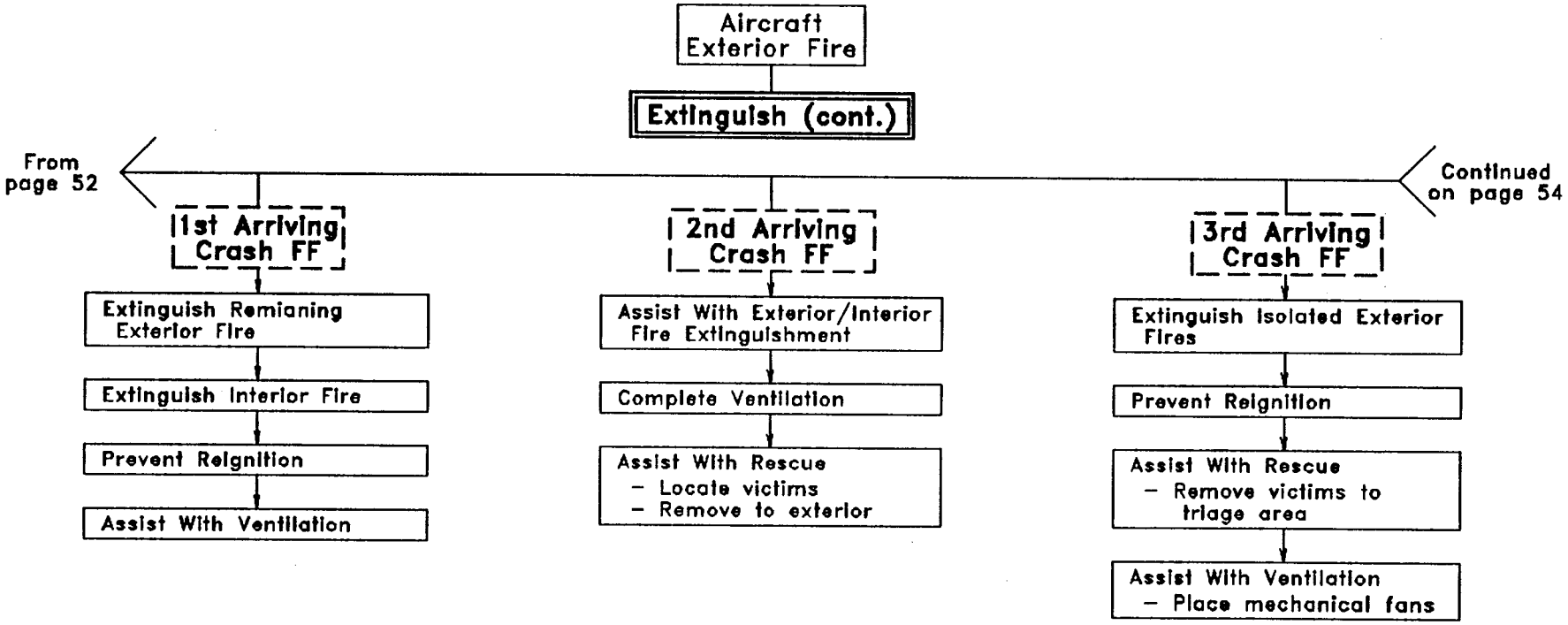
USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Extinguish Tasks
(A/C Exterior Fire)
Level 04
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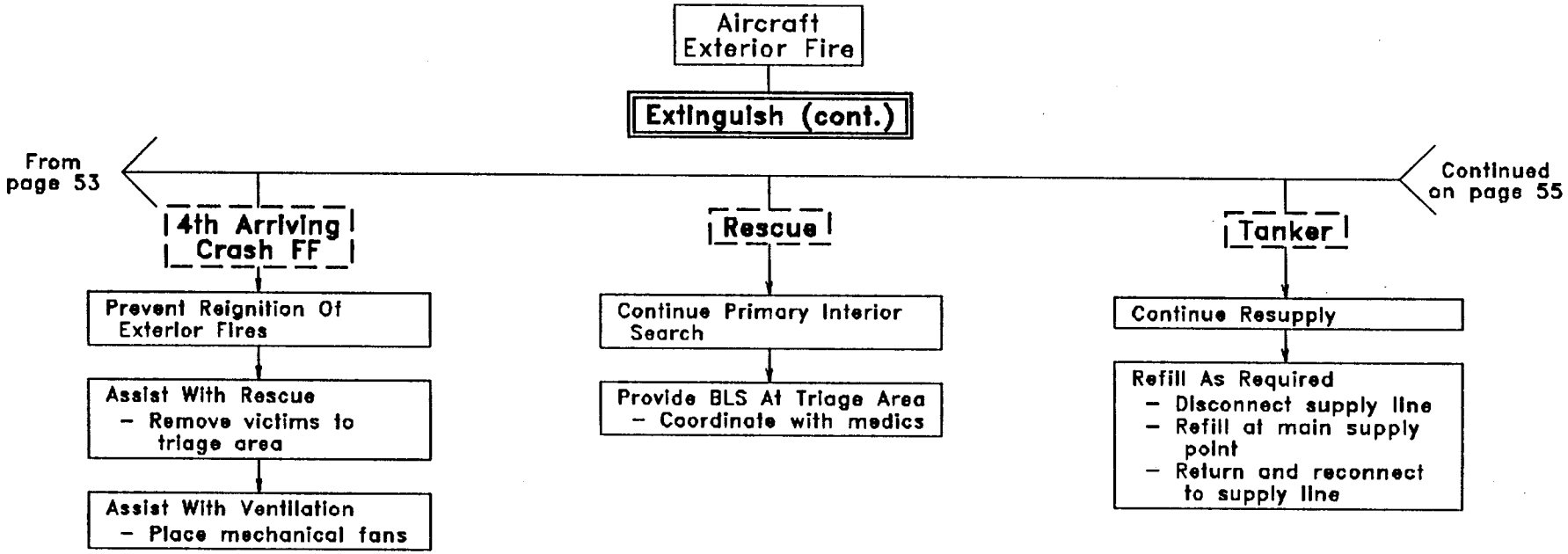
USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Extinguish Tasks
(A/C Exterior Fire)
Level 04
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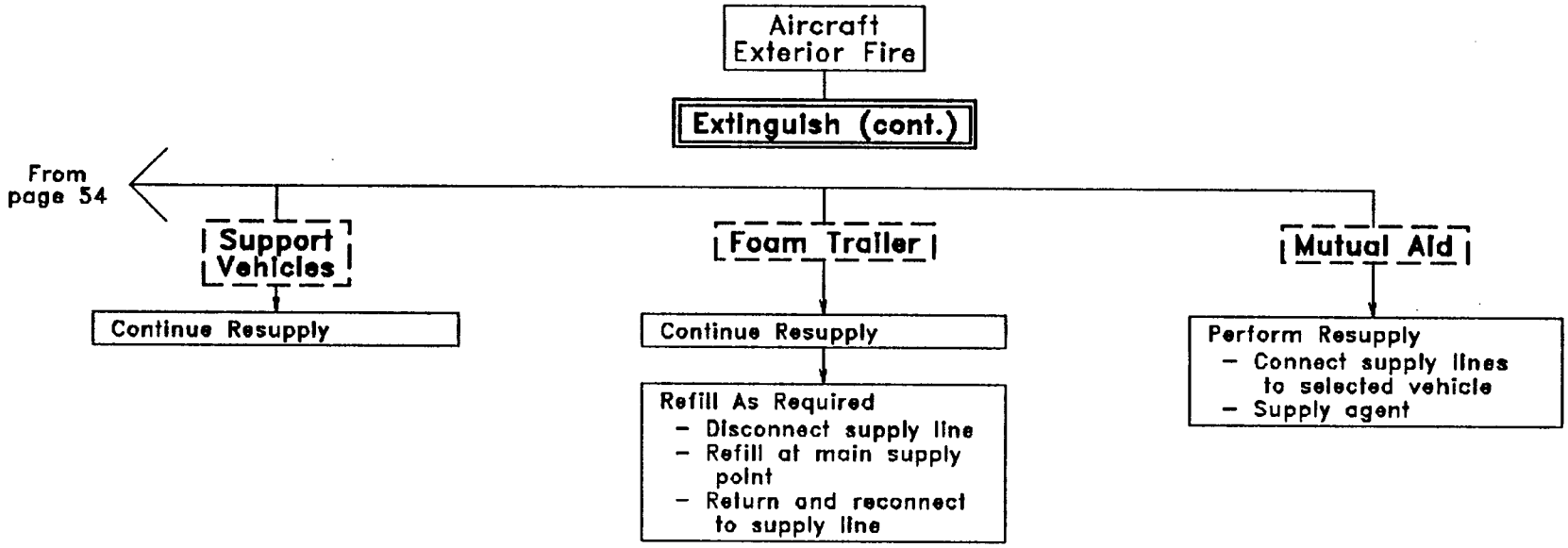
USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Extinguish Tasks
(A/C Exterior Fire)
Level 04
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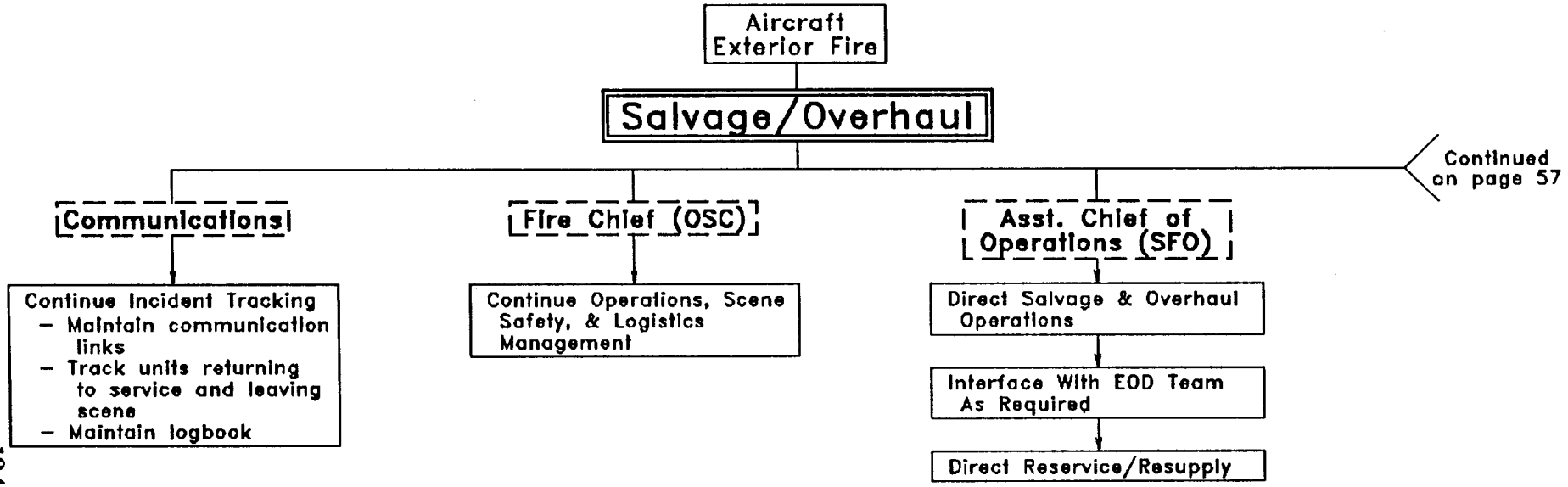
USAF INSTALLATION FIRE DEPARTMENT

Task Oriented WBS



Salvage/Overhaul Tasks
(A/C Exterior Fire)
Level 04
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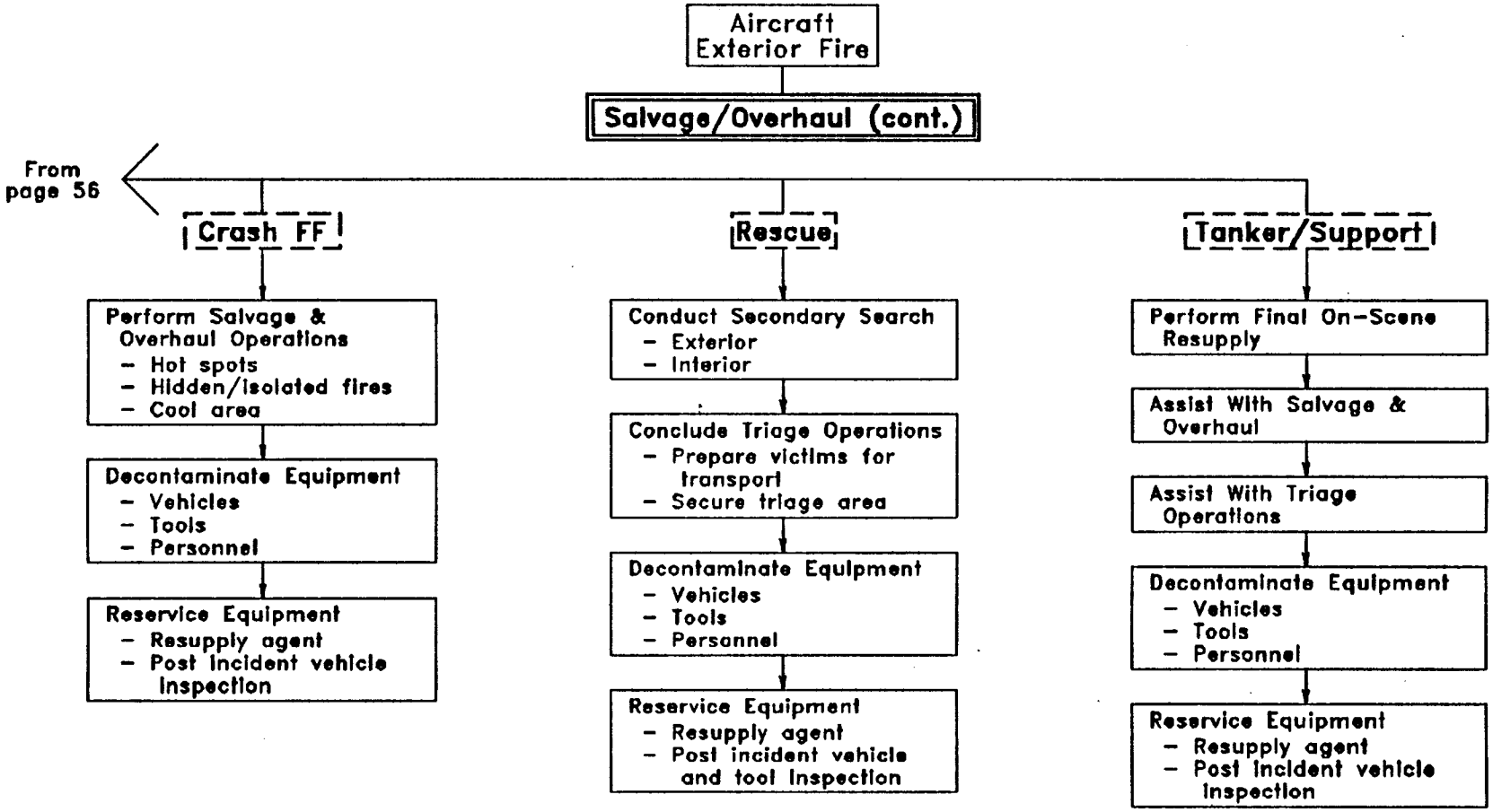
Task Oriented WBS



Salvage/Overhaul Tasks
(A/C Exterior Fire)
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APPENDIX B
STATISTICAL ANALYSIS

STATISTICAL METHODS USED IN ANALYSIS

The mean value of a loss measure was determined for each 1-minute response time interval. The mean value for each response time was determined with the statistical program SPSS. Two types of 95 percent confidence intervals were placed on the averaged data: an absolute 95 percent confidence interval was determined for the total dollar loss and a relative 95 percent confidence interval was placed on the percent dollar loss and the extent of flame and smoke damage.

An absolute 95 percent confidence interval requires a relatively normal distribution. The interval denotes a range where it is 95 percent certain the true value will fall between. This interval is a function of the number of incidents and the standard deviation of them. If it is assumed that the number of incidents for a particular response time and category are a random sample of a much larger number, the 95 percent confidence interval for the interval for the mean value of the larger sample (μ) is computed via

$$\mu = \bar{X}_s + -t_{\frac{\alpha}{2};n-1} \cdot \frac{S_s}{n^{\frac{1}{2}}}$$

where $\bar{X}_s$ is the random sample mean, $t_{\alpha/2;n-1}$ is the t distribution for the $100(1-\alpha)$ percent confidence interval (see Section III.V.1), S_s is the standard deviation of the random sample, and n is the number of incidents in the random sample.

A relative 95 percent confidence interval compares the deviation of response time intervals with few incidents to the response time with the greatest number of incidents. It can be interpreted as a range that it is 95 percent certain that the value would be as accurate as the value with the greatest number of incidents. It says nothing about the accuracy of the value on the response time with the greatest number of incidents. It is assumed that the mean values of many random sub-samples of the response time interval with the greatest number of incidents will be normally distributed about its mean. It is also assumed that the distribution of the mean values of the sub-samples is a reasonable measure of the likely deviation of the mean value for other response time intervals with a similar number of incidents around a value that would be obtained with a larger number of incidents. The standard deviation of all possible combinations of sub-samples around the mean value is given by

$$\bar{\sigma} = \sigma\sqrt{\frac{N-n}{n(N-1)}}$$

Where $\bar{\sigma}$ is the standard deviation of the samples around the mean value of the complete data set, σ is the standard deviation of the complete data set, N is the number of

incidents in the data set, and n is the number of incidents in the sample. Since the mean value of all the sample means is equal to the mean value of the complete data set (μ), once the standard deviation of the samples are known around the mean, 95 percent relative confidence interval will lie in between

$$\mu \pm 2\,\bar{\sigma}$$

for the sample of the response time. The 95 percent confidence interval can be converted to a percentage of the value and applied to other response times with an equal sample size.

REFERENCES

B1 Bowker, A., and Lieberman, G.J., Engineering Statistics, 2nd Edition, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1972.

B2 Alder, H.L., and Roessler, E.B., Introduction to Probability and statistics, W. H. Freeman and Company, San Francisco, CA, 1960.

B3 Parl, Boris, Basic Statistics, Doubleday & Company, Garden City, NY, 1967.

APPENDIX C
APPLICATION OF RESPONSE TIME CORRELATIONS

DESCRIPTION OF METHOD

The data in Appendix B may be used to make an estimate of the dollar loss associated with adding or removing fire stations. An approximation of the dollar loss requires three steps:

(1) Estimate the number of fire incidents per year in the area to be serviced by the proposed station;

(2) Estimate the average response time in the affected area before and after the addition or removal of the fire station; and

(3) Determine the dollar loss expected for the new condition using the appropriate figures and tables.

The number of fire incidents per year in the area to be served by a proposed station can be inferred by personnel familiar with the district. The total number of incidents at a base can be determined from the Air Force database. Base personnel can make an estimate of the fraction of incidents in the area under consideration. The number must not include false alarm incidents and fires that were not controlled by the fire department. From the analysis in Appendix B, it was determined that about 3/8 of all reported incidents involved a fire that was controlled by the fire department and had a fixed property classification. This value of 3/8 is variable and depends on the base.

The historical average response time is most likely 2 or 3 minutes. The change in the average response time to incidents in an affected area may be estimated by using a distance-time correlation developed by the Rand Institute in the 1970's (C.1):

$$\textit{Response Time}\ (\text{min}) = 0.69 + 1.69 \times \textit{Distance}\ (\textit{mi}) \qquad \text{(C1)}$$

The average response time change for all occupancies could be approximated as the travel time between the main fire station and the proposed additional station or removed station.

The evaluation of the change in losses can be accomplished either by directly using the dollars lost graphs or by converting the data in the percent lost graphs to a dollar loss with the average property value of a region. Due to the wide scatter of the data for the occupancies with few incidents, it is suggested that if the area is chiefly residential, that the residential graphs be used. Otherwise, use the all fixed dwellings results.

Since the dollars lost graphs do not include zero losses, the resulting value must be multiplied by one minus the probability of an incident with zero loss. The total increase in dollar loss can be approximated with one of the following equations:

1. Use of Dollar Loss Results

$$\frac{\Delta \ Dollars \ Lost}{year} = [(1-P_{0,new})DL_{new} - (1-P_{0,old})DL_{old}](\frac{3}{8}I) \qquad (C2)$$

where $P_{0,new}$ = Probability of a no loss incident in the new allocation scheme,
$P_{0,old}$ = Probability of a no loss incident in the old allocation scheme,
DL_{new} = Average dollar loss in the new allocation scheme (June, 1993 US Dollars),
DL_{old} = Average dollar loss in the old allocation scheme (June, 1993 US Dollars), and
I = The number of incidents in the area affected by the reallocation. This is the number of incidents that would be reported and recorded in the Air Force Database. (note: 3/8 is the fraction of calls where the fire department extinguished the fire. This was determined using SPSS to filter out false calls, fires put out by a sprinkler systems, etc. Of the nearly 8000 incidents recorded in the database, approximately 3000 were retained. Presumably, the 8000 represents all incidents. However, it is likely that there were a number of inconsequential and unreported incidents. This issue would need to be addressed by the local Air Force Fire Department.)

2. Use of Percent Loss Results

$$\frac{\Delta DollarsLost}{year} = \frac{[PL_{new}-PL_{old}]}{100} \bar{V} (\frac{3}{8}I) \qquad (C3)$$

where PL_{new} = Average percent loss of occupancy and contents for the new allocation scheme,
PL_{old} = Average percent loss of occupancy and contents for the old allocation scheme,
V = Average value of the occupancy and contents in the area affected by the reallocation scheme, and
I = The number of incidents in the area affected by the reallocation scheme

The values for the probability of a zero loss (P), the total dollar loss per response time (DL), and the percent loss per response time (PL) in the above equations can be determined from the results of Appendix B. A linear curve fit was used to

approximate the correlation for P, DL, and PL as a function of the response time for the residential dwellings and All fixed occupancies (refer to corresponding figures in main part of the text):

$$value\ of\ P, DL,\ or\ PL = a + b\,T \qquad \text{(C4)}$$

where a and b are constants from Table C1, and T is the response time in minutes. For the old values of P, DL, and PL, a typical response time of two or three minutes is suggested.

TABLE C1. LINEAR CONSTANTS FOR P, DL, AND PL

	P		DL		PL	
	a	b	a	b	a	b
Residential	0.651	-0.028	1994	553	9.79	1.54
All fixed	0.492	-0.027	1402	503	21.7	3.37

Equations C2 and C3 are applicable as long as there are no major changes that would alter either:

(a) The number of incidents that occur in a given region that are put out by the fire department, or

(b) Complete changes in the ability of structures to withstand fire.

The former can be accounted for by replacing the $3/8^{\underline{ths}}$ factor in equations C2 and C3 by the new ratio of fire department controlled incidents to total number of incidents. The latter would require a whole new analysis to develop new correlations between the response time and the expected amount of damage and/or dollar loss. In addition, since equation B2 yields losses in June 1993 dollars, Inflation corrections will need to be applied to the equations, depending on the future inflation rates.

EXAMPLE OF APPLICATION

A simple example will illustrate the method outlined in the first section of this appendix. Consider an Air Force base with two fire stations. One station services a predominantly residential area and the other services base operations, manufacturing, and residential areas. The stations are located two miles apart. It is has been proposed to close down the station in the residential area, and it is suspected that the longer response times to the residential region will increase the severity of fires and the total cost of the loss. It was estimated by local personnel that the residential fire station averaged 200 calls per year, of which 125 calls per year were in the area affected by the relocation.

The average increase in response time to the residential area can be evaluated with the use of equation C1. The average response time before the elimination of the residential station is assumed to be 2 minutes. The increase in response time can be found with equation C1 using the distance between the two fire stations, 2 miles, as the average increase in distance to the affected region. This gives an average increase of 4 minutes, or an average response time of 6 minutes.

The increase in the dollar loss as a result of the increased response time can deduced with equations C2 and C4 and Table C1. Using an old response time value of 2 minutes, a new response time value of 6 minutes, and the residential curve fit parameters, the variables in equation C2 become:

$P_{0,new}$	=	0.483
$P_{0,old}$	=	0.595
DL_{new}	=	5312 dollars/incident
DL_{old}	=	3100 dollars/incident
I	=	125 incidents/year

so that the estimated loss as a result of the increased average response time is $69,800 per year.

If it were known that the average property value of the residential occupancies was $50,000 (perhaps a small apartment), equation C3 could be used instead of C2 to give a more precise local value. In such a case, using the same response times, the variables in equation C3 become

PL_{new}	=	19.0 percent/incident
PL_{old}	=	12.9 percent/incident
V	=	50,000 dollars
I	=	125 incidents/year

which results in an average of $143,000 per year additional cost due to the delayed response time. The difference in results between equation C2 and C3 is a reflection of the amount of information known. Equation C2 represents a general loss function, applicable to any residential occupancy. However, since equation C2 is derived from all recorded residential fires, there is a wide variation in the property value. This is because there are situations that resulted in a small percentage of damage but incurred a large cost and conversely there are incidents that do a large percentage of damage but incur little cost (take for instance an abandoned residential house). Equation C3 was derived from values that are independent of the property value. Thus, when the average property value is known (or not completely mixed), then Equation C3 would yield better results for the situation at hand.Walker,

REFERENCES

C1 Warren, E., "Applied Systems Analysis to the Fire Service," June 1975.

QUESTIONNAIRE

We believe that reports from users provide valuable information for producing quality technical documents. By taking a few minutes to answer the following questions as they relate to this specific document, you can take an active role in the continuing effort to ensure our technical efforts contain the most accurate and complete information of benefit to you. Thank you for your cooperation.

In reference to: **Technical Report DF-TR-94-10, Air Force Fire Protection Cost Risk Analysis**

1. Please check all the appropriate boxes:

	Complete	Incomplete	Correct	Incorrect	Clear	Confusing	Useful	Not Useful	Not Reviewed
Executive Summary									
Section I Introduction									
Section II Comparison of USAF/Civilian									
Section III USAF Response Time									
Section IV Civilian Response Time									
Section V Cost Model									
Section VI Conclusion									
Figures/Tables /References									
Appendix A Work Breakdown Structure									
Appendix B Statistical Analysis									
Appendix C Application of Response Time									

2. How would rate the overall organization of the document?
   ☐ excellent ☐ very good ☐ good ☐ fair ☐ poor

3. How would rate the overall technical content of the document?
   ☐ excellent ☐ very good ☐ good ☐ fair ☐ poor

4. Is the information in this document essential to cost/risk analysis of USAF fire protection?
   ☐ very much so ☐ generally yes ☐ to some extent ☐ no

5. Is the information in this document helpful in the technical execution of your responsibilities?
   ☐ very much so ☐ generally yes ☐ to some extent ☐ no

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6. We would appreciate any corrections or recommendations for improving this document. Please include the specific page number(s) of the text, figure or table in question, along with any correction or recommendations for improvement.

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